List of 'First Cut' References with Abstracts

Supplement to:

A review of studies on responses of salmon and trout to habitat change, with potential for application in the Pacific Northwest

By

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List of ‘First Cut’ References with Abstracts

The references and abstracts in this supplementary document were analyzed and reviewed for “A review of studies on responses of salmon and trout to habitat change, with potential for application in the Pacific Northwest,” by Peter B. Bayley, as reported to the Washington State Independent Science Panel in May, 2002. The 441 ‘first cut’ documents listed here resulted from a search in Cambridge Scientific Abstracts (CSA). In some cases the CSA abstracts listed below were incomplete. In addition, information was not always complete for “gray” literature references. “Codes” at the end of each reference represent the classification as described in Appendix 2 of the above report. Observations and annotations by the author are marked within # … # symbols.

Alexander, G. R., and E. A. Hansen. 1983. Sand sediment in a Michigan trout stream Part 2. Effects of reducing sand bedload on a trout population. North American Journal of Fisheries Management 3: 365-372.

This is the second of a two-part sedimentation study. A sediment basin excavated in a Michigan trout stream reduced the sandy bedload sediment by 86% (from 56 ppm down to 8 ppm). Following the reduction in bedload, trout numbers increased significantly during the next 6 years. Small or young trout increased about 40% throughout the treated area. Larger and older trout increased in that part of the treated area that had an erodible sand bed. Although trout production increased 28%, growth rate of the trout changed but little. Both brown trout (Salmo trutta) and rainbow trout (Salmo gairdneri) populations responded similarly to the bedload reduction. The results suggested that in-stream sediment basins are an effective means for removing sand bedload and that even small amounts of moving-sand bedload sediments can have a major impact on a trout population.

Codes: reach quant substrate temporal

Alexander, G. R., and E. A. Hansen. 1986. Sand bed load in a brook trout stream. North American Journal of Fisheries Management 6: 9-23.

An experimental introduction of sand sediment into Hunt Creek in the northern Lower Peninsula of Michigan that increased the bed load 4-5 times resulted in a significant reduction of brook trout (Salvelinus fontinalis) numbers and habitat. The brook trout population declined to less than half of its normal abundance. The growth rate of individual fish was not affected. Population adjustment to the poorer habitat was via a decrease in brook trout survival rates, particularly in the egg to fry and/or the fry to fall fingerling stages of their life cycle. Habitat for brook trout and their food organisms became much poorer, as judged by the drastic reductions of both. Stream morphometry changed considerably, the channel becoming wider and shallower. Furthermore, sand deposition aggraded the streambed and eliminated most pools. The channel became a continuous run rather than a series of pools and riffles. Water velocities increased, as did summer water temperatures. Relatively small sand bed-load concentrations of only 80 ppm had a profound effect on brook trout and their habitat.

Codes: reach quant popdyn instream substrate temporal

Amiro, P. G. 1989. Remote surveying of juvenile Atlantic salmon stream habitat, documentation of use and erivation of pro-rated production models. Report; Conference; Summary SAF 89-05. multi reach quant instream.

A procedure to derive quantitative juvenile Atlantic salmon (Salmo salar) habitat information by using aerial photographs and orthophotographic maps together with fish density distribution curves is presented and tested. The technique allows for the near complete coverage of a river system in a systematic and quantitative computer model. Viewable water surface area, corrected to a standardized summer low width, is summarizeable on a tributary, branch or complete river system basis in a distance and stream gradient interval matrix. Photo measured area was estimated with a 15% negative bias of proximate measured area. Stream gradient was estimated with substantial positive bias.

Total parr densities estimated by electrofishing at 114 sites on the Stewiacke River and 64 sites on the St. Mary's River, Nova Scotia, Canada, were significantly distributed in a quadratic or negative exponential manner with respect to stream gradient. Optimum stream gradient was about 2% on the orthophotographic maps or about 1% proximate measured surface grade. The technique provides a basis to derive systematic estimates of habitat pro-rated production for Atlantic salmon streams for which there is photo coverage. Incorporation of an optimum production density curve would allow river-specific estimates of required spawning escapement. #summary only#.

Codes: multi reach quant instream

The rivers of Labrador. Canadian Special Publication of Fisheries and Aquatic Sciences 81: 397.

Physical and biological data are presented for 120 river systems in Labrador. Past and present developments within the watersheds are documented. Physical data presented include characteristics of each drainage system, and locations and descriptions of obstructions to fish passage. The size and location of salmonid rearing and spawning habitat are presented for 82 rivers. The distribution within Labrador of 24 freshwater, anadromous and catadromous fishes is summarized. Emphasis is placed on the production and freshwater exploitation of Atlantic salmon (Salmo salar). Production estimates, based on available rearing habitat for salmon parr, are presented for 60 rivers. Catch/effort data from the commercial fishery for Arctic char (Salvelinus alpinus) in northern Labrador are tabulated.

Codes: multi reach habitat qual spawn instream

Annoni, P., I. Saccardo, G. Gentili, and L. Guzzi. 1997. A multivariate model to relate hydrological, chemical and biological parameters to salmonid biomass in Italian Alpine rivers. Fisheries Management and Ecology [Fish. Manage. Ecol.] 4: 439-452.

A multivariate statistical analysis was performed to assess the relationships between a series of river habitat parameters and the variation in salmonid biomass in 13 stations in Italian Alpine salmonid rivers. Various river data were collected and principal component analysis was used to identify the relevant parameters. The best regression model was calculated using two statistics: Mallows' Cp and R super(2) adjusted for degrees of freedom. The best model only uses six parameters and explained 89% of variation in fish biomass. Various statistical indices were calculated to evaluate model quality and robustness. A sensitivity analysis was carried out to determine how the model slope would change due to independent measurement errors in the parameters. These effects were mostly negligible. This demonstrated that it is possible to simplify habitat quality evaluation using a subset of environmental parameters which should be useful for river management.

Codes: multi reach quant instream

Anon. 1977. Comparison of coastal cutthroat trout populations in allopatry and those sympatric with coho salmon and sculpins in several small coastal streams on Vancouver Island, B.C. Report

Biomass density and growth of summer stocks of coastal cutthroat trout (Salmo clarki) populations above (allopatric) and those below barrier falls sympatric with coho salmon (Oncorhynchus kisutch) and sculpins (Cottus spp.) were compared in six small coastal streams on Vancouver Island, B.C. Range in mean fish biomass densities in allopatric trout populations was 1-6 g/m SUP-2 (GX = 2 . 2 g/m SUP-2), whereas sympatric populations of coho, trout, and sculpins combined was 2-9 g /m SUP-2 (GX = 5 . 1 g/m SUP-2), with trout contributing less than 1 g/m SUP-2 in all habitats. Biomass density of allopatric trout populations approximated that of the combined populations of sympatric trout and coho. Mean body size for grouped age classes and summer growth of age O trout were significantly less in sympatric than in allopatric trout populations. In stream simulator studies, microhabitat use and aggressive behavior were similar for both trout types when tested separately, other than that sympatric trout defended riffle territories more vigorously, responded to the feeding cycle with greater synchrony, and used components of aggressive display hydromechanically more suited to fast water habitats, than did allopatric trout.

Codes: multi experi sppinter quant noenv

Anon. 1977. Interactions for food and space between sympatric populations of juvenile coho salmon and coastal cutthroat trout in a stream simulator during winter and spring. Report

Interactions for food and space between sympatric populations of underyearling coho salmon (Oncorhynchus kisutch) and coastal cutthroat trout (Salmo clarki) were investigated in a stream simulator during winter and spring. Temperature was the main determinant of coho and trout microhabitat use in winter. At 3 degree C, both species almost exclusively occupied pools, whether in allopatry or in sympatry. At 5 degree C, minor segregation was evident, with species relative abundance in riffles being higher for trout and in pools for coho. Factorial analyses of variance indicated temperature, size of fish, water velocity and simulated food supply were ranked (high to low) as affecting microdistribution. Coho and cutthroat trout fry communicated using the same signal set as in summer with chases, nips and lateral displays comprising more than 80% of their total aggressive activity. Non-contact behaviors were more frequently used by coho; nipping was more frequently used by trout. Both salmonids were most aggressive when food was present, irrespective of temperature. However, levels of aggressiveness differed with temperature and space: at 3 degree C, aggression was low and neither species defended riffles; at 5 degree C, aggression was higher and both species actively defended riffles during feeding. Patterns of species microhabitat use and behavioral interactions in spring were similar to, but more pronounced than those in winter at 5 degree C. Stream management strategy should take into account the importance of providing adequate winter cover appropriate to the different age-classes in sympatric populations of coho salmon and coastal cutthroat trout.

Codes: habitat qual sppinter instream wtemp

Anon. 1977. Interactions for food and space between sympatric populations of underyearling coho salmon and coastal cutthroat trout in a stream simulator during summer. Report

Interactions for food and space between sympatric populations of underyearling coho salmon (Oncorhynchus kisutch) and coastal cutthroat trout (Salmo clarki) were investigated in a stream simulator during summer. In sympatry, partitioning of space was rapid and similar to that in nature, in that coho numerically dominated pools and trout dominated riffles. In allopatry, their microhabitat use was similar, in that 60-75% of either species occupied pools. Factorial analyses of variance indicated that size of fish, simulated food supply and water velocity were ranked (high to low) as affecting microdistribution. Coho and cutthroat trout fry communicated using an array of similar body postures and movements, with chases, nips and lateral displays comprising more than 80% of their total aggressive activity. Non-contact behaviors were more frequently used by coho; nipping was more frequently used by trout. Both salmonids were most aggressive when food was present. Species levels of aggressiveness were similar in allopatry, but differed between habitat types in sympatry, coho being more inclined to defend pools and trout riffles. Stream management strategy should take into account the importance of maintaining habitat diversification in streams supporting sympatric populations of coho salmon and cutthroat trout.

Codes: habitat qual sppinter instream

Anon. 1997. Investigation of the habitat and production of sea trout (Salmo trutta L.) in tributaries to the River Laerdal (Norway). Institutt for Fiskeri og Marinbiologi [IFM RAPP.], Nov

Densities of sea trout (Salmo trutta L.) parr and alevins in 10 tributaries (small rivers and creeks) to the River Laerdal beneath the Sjurshaug waterfall in Laerdal County, Western Norway, were estimated by electrofishing in September-October 1996. This was done to investigate the importance of these tributaries to the total population of sea trout in the River Laerdal. Sea trout were found in 7 of 10 tributaries, while no fish were caught in the remaining 3 tributaries. Smolt production in the different rivers were also calculated, indicating a total smolt production of about 5800 sea trout smolt annually. Our results indicate that only 2% of the total annual production of sea trout smolts originate in the tributaries, while 98% is produced in the main fiver. In one river, River Nivla, parr and alevins of Atlantic salmon (Salmo salar L.) were also found.

Codes: multi reach quant noenv foreign

Anon. 1997. Investigations of the habitat and production of the sea trout (Salmo trutta L.) in small rivers and creeks in Kvam county, Hordaland (Norway)

Densities of sea trout (Salmo trutta L.) parr and alevins in 25 small rivers and creeks in Kvam County, Western Norway, were estimated by electrofishing in September-October 1996. 21 of 25 rivers held sea trout, while no fish were caught in the remaining 4 rivers. Smolt production in the different rivers were also calculated, indicating a total smolt production of about 17.000 sea trout smolt annually. In 6 rivers, parr and/or alevins of Atlantic salmon (Salmo salar L.) were also found, with a total smolt production of about 3000 salmon annualy. Salmon parr found in two very small creeks are probably the offspring of escaped farmed salmon. Adult sea trout infestated with sea lice were found in 6 rivers, and 58% of all adult sea trout were injured by the lice.

Codes: multi reach quant noenv foreign

Anon. 1997. Kalispel resident fish project. Annual report, January 1, 1995--December 31, 1995.

In 1995 the Kalispel Natural Resource Department (KNRD) in conjunction with the Washington Department of Fish and Wildlife (WDFW) initiated the implementation of a habitat and population enhancement project for bull trout (Salvelinus confluentus), westslope cutthroat trout (Oncorhynchus clarki lewisi) and largemouth bass (Micropterus salmoides). Habitat and population assessments were conducted in seven tributaries of the Box Canyon reach of the Pend Oreille River. Assessments were used to determine the types and quality of habitat that were limiting to native bull trout and cutthroat trout populations. Assessments were also used to determine the effects of interspecific competition within these streams. A bull trout and brook trout (Salvelinus fontinalis) hybridization assessment was conducted to determine the degree of hybridization between these two species. Analysis of the habitat data indicated high rates of sediment and lack of wintering habitat. The factors that contribute to these conditions have the greatest impact on habitat quality for the tributaries of concern. Population data suggested that brook trout have less stringent habitat requirements; therefore, they have the potential to outcompete the native salmonids in areas of lower quality habitat. No hybrids were found among the samples, which is most likely attributable to the limited number of bull trout. Data collected from these assessments were compiled to develop recommendations for enhancement measures. Recommendations for restoration include riparian planting and fencing, instream structures, as well as, removal of non-native brook trout to reduce interspecific competition with native salmonids in an isolated reach of Cee Cee Ah Creek.

Codes: multi reach sppinter substrate quant?

Armstrong, J. D. 1997. Self-thinning in juvenile sea trout and other salmonid fishes revisited. Journal of Animal Ecology [J. Anim. Ecol.] 66: 519-526.

Self-thinning, the reduction in density (N) as a consequence of the increase in the mean weight (W) of individuals, occurs widely in populations of plants when their growth is constrained at high densities, but has only recently been reported to occur within populations of wild mobile animals. It has been suggested that a self-thinning relationship in which the gradient (Delta log (W) / Delta log (N)) approximates to -1 times 33 describes concomitant changes in W and N within cohorts of a population of anadromous brown trout (sea trout) Salmo trutta throughout their lives as juveniles in fresh water. This apparent self-thinning occurs with no evidence of density-dependent growth or mortality (as measured by key-factor analysis) after the critical period. Here, the relationship between weights and densities of trout has been examined further. A linear model incorporating log (N), year class and time of year explained 99 times 5% of the variation in log (W), giving a significantly better fit than incorporating onlylog (N) and year class. Variation in log (N) explained 85% of the variation in log (W); the addition of year class increased this value by 6% and the addition of monitoring period increased it by a further 8 times 5%. The gradients for the relationships between log (W) and log (N) within years varied significantly with time of the year. Pooled thinning trajectories for the first winter of the life of trout differed significantly from a gradient of -1 times 33, while those for the second summer were highly variable and sometimes positive (suggesting that immigration could exceed mortality). Thinning trajectories over the first summer of life were related inversely to the densities of trout at the start of the monitoring period in that summer (N sub(s)), but this relation appeared to approach an asymptote at high values of N sub(s). The mean of the thinning trajectories for cohorts with high N sub(s) (exceeding 300 fish 60 m super (-2)) was not significantly different from -1 times 33. However, these slopes were shown to result primarily from the presence of high numbers of failed non-territorial fish early in the summer rather than true thinning throughout the summer. The apparent absence of a simple consistent thinning relationship after a critical period in the first couple of months of the lives of cohorts can be explained by three factors. First, the total availability of limiting resources, such as space and food, is not constant but changes with the mean size of the trout. Secondly, there is a winter cessation of growth. Thirdly, trout switch to use different habitats during their development. The implications for interpreting thinning relationships for salmonid fishes in general are discussed.

Codes: multi reach quant popdyn noenv temporal

Armstrong, J. D., V. A. Braithwaite, and M. Fox. 1998. The response of wild Atlantic salmon parr to acute reductions in water flow. Journal of Animal Ecology 67: 292-297.

A seasonal reduction in water flow, due both to prevailing weather conditions and anthropogenic disturbance, is a prominent feature of the habitat in many riverine systems, yet the response of many aquatic vertebrates, such as juvenile Atlantic salmon, to low flows is not well understood. However, in accordance with general fitness optimization theory, it might be predicted that salmon will emigrate from shallow areas to seek refuge in pools as water levels decrease to critically low levels (fitness approaches zero). To test this prediction, we directly measured the movement response of individual Atlantic salmon (Salmo salar L.) (74-109 mm) to drought in near-natural mesocosms. 2. In five separate trials during summer, groups of salmon were introduced into enclosed 30-m long sections of stream, each comprising a central 10-m long region of shallow riffle habitat bordered upstream and downstream by 10-m long regions of deeper water. After fish had settled into home ranges, those fish inhabiting deep areas were removed and the water flow was later decreased to zero over 2 days, so that the riffles were nearly dry. The movements of each individual fish within the enclosures were monitored remotely and continuously using a passive integrated transponder (PIT) tracking system. 3. Of the total of 33 fish with home ranges that included only riffle habitat, 14 moved into deep water at some point during drought, but only seven of these fish (0-50% between trials) established new home ranges that included deep areas. The others returned to regions of riffle during the drought. None of the eight fish that definitely had not sampled in pool habitat prior to settling on riffle emigrated during drought. 4. The optimal response of salmon parr to moderate natural drought appears not to be fixed, but for many individual fish it may be to stay in shallow riffle areas. The optimal response of salmon parr to extreme natural drought and anthropogenic dewatering will, in many cases, be to move. An increase within the population of traits that promote an ideal response to natural drought will therefore make it more vulnerable to severe drought and anthropogenic de-watering and vice versa. 5. The absence of emigration by salmon from shallow areas during acute drought can be reconciled with fitness optimization theory if, when natural drought progresses, fish become stranded in shallow areas some considerable time before the point at which they die.

Codes: experi enclos reach qual migrat instream

Armstrong, J. D., V. A. Braithwaite, and F. A. Huntingford. 1997. Spatial strategies of wild Atlantic salmon parr: exploration and settlement in unfamiliar areas. Journal of Animal Ecology 66: 203-211.

Relationships between distributions of animals and the resources they use can be expected to depend critically on the mobility of individual animals within populations. However, there is little information on the movements of individuals within populations of animals in most natural aquatic systems, so it is difficult to model accurately the processes that underlie their distributions. Aspects of the processes involved in the colonization of vacant areas by stream-resident Atlantic salmon Salmo salar (69-114 mm length) were measured under near-natural conditions. In five separate trials over summer months, groups of salmon were introduced into enclosed 30-m long sections of stream, each comprising three distinct 10-m long regions of habitat. The subsequent movements of each individual fish within the enclosures were monitored remotely and continuously using a passive integrated transponder (PIT) tracking system. Considerable variation was observed between the activity of different individual salmon. Some of the fish (range between trials, 3-33%) settled into localized home ranges without moving between regions, 10-38% of the fish moved within two regions, and 37-87% of the salmon moved through all three regions of their enclosure. A fraction (0-20%) of some of the populations was particularly mobile and never settled but continued to move throughout all three regions of the enclosure. Within the scale of this current study, it would appear that, for territorial animals such as salmon parr, certain members of the population will settle in new territories after very little exploration of their new environment. The propensity to explore was independent of habitat type, but was directly proportional to the size of the fish. The time from release until 50% of fish in populations settled (excluding the mobile fraction) ranged from 0.3 to 2.4 days. Activity levels were particularly high and initial movements by fish were directed upstream in trial 1, early in the summer, perhaps reflecting upstream migration by salmon parr within the population of the burn at this time.

Codes: experi reach qual popdyn migrat noenv

Armstrong, J. D., J. W. A. Grant, H. L. Forsgren, K. D. Fausch, R. M. DeGraaf, I. A. Fleming, T. D. Prowse, and I. J. Schlosser. 1998. The application of science to the management of Atlantic salmon (Salmo salar): integration across scales. Canadian Journal of Fisheries and Aquatic Sciences 55: 303-311.

The need for integration across spatial and temporal scales in applying science to the management of Atlantic salmon is considered. The factors that are currently believed to affect the production of anadromous adult Atlantic salmon (synthesized from recent reviews) are arranged in a hierarchy in which any given process overrides those processes at lower levels. There is not a good correlation between levels in the process hierarchy and levels in hierarchies of scale. This demonstrates the importance of integrating across scales in identifying the optimum foci for targeting management action. It is not possible to generalize on the need for integration across scales within management plans. This is because of the complex ecology of salmon, the broad range of characteristics of the systems of which they are a part, and the fact that both local scale and broad scale management can have broad scale effects. Many uncertainties remain regarding the large-scale components of the ecology of salmon, the way that small-scale mechanisms interact with life histories, and the way that different factors interact to limit production of fish. When more is understood of these processes, it is likely that generalized rules might be developed to predict the management requirements for stream systems. In the meantime, it is essential that there is good integration among managers working at different scales and it is important that management systems operating at all spatial scales include highcalibre expertise to compensate for the present paucity of general rules.

Codes: review philosophy multi reach qual temporal lulc

Armstrong, J. D., F. A. Huntingford, and N. A. Herbert. 1999. Individual space use strategies of wild juvenile Atlantic salmon. Journal of Fish Biology [J. Fish Biol.] 55: 1201-1212.

Movements of 60 stream-dwelling wild Atlantic salmon Salmo salar (97-118 mm), each tagged with a passive integrated transponder, were monitored during four trials in an enclosed section (24 m long, 45.1 m super(2) total area) of a stream at a range of densities (four, eight, 16 and 32 fish per enclosure). Patterns of space use differed markedly between individuals, with 80% of fish establishing home ranges within 8 days of introduction to the enclosure (settlers) and the remainder continuing to move throughout the length of the enclosure (non-settlers). Although aggressive interactions were quite frequent and dominant fish were observed chasing subordinates, there was considerable overlap of home ranges of settlers at all densities; this was the case even at lower densities at which only a fraction of the enclosure was used by the fish. Thus, rather than adopting fixed territories, the salmon showed a high level of space sharing. Individual fish used the same local area in different ways, ranging from highly localized feeding on drifting food items to a wider-ranging strategy of specialising on benthic food. Among the fish that settled absolute growth rates were inversely related to body size, and at high densities fish lost weight. These results suggest that space use in wild juvenile salmon is more complex than a mosaic of territories, that salmon demonstrate significant variability in individual space use patterns, and that large fish may suffer disproportionately when populations are at the carrying capacity of their environment.

Codes: experi enclose quant migrat habitat

Armstrong, J. D., P. E. Shackley, and R. Gardiner. 1994. Redistribution of juvenile salmonid fishes after localized catastrophic depletion. Journal of Fish Biology 45: 1027-1039.

Juvenile Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) were depleted at three sites (c. 108-380 m super(2)) of a natural stream during the summer months of 1991 and 1992. Local population changes and movements of fish marked in sections adjacent to each depleted area were monitored thereafter. There was very little movement of marked salmon parr into the central regions of the depleted areas following the immediate post-marking period. Upstream movement by young-of-the-year fish from high density sections in mid-late summer was noted for trout but not salmon. Unmarked 1-year-old salmon parr immigrated into depleted areas in June 1992, and the pattern of recolonization was consistent with migration upstream from the adjoining river. It is concluded that resident salmon were very strongly site-attached and resource tracking was of no functional significance as a compensatory mortality mechanism. The occurrence of a long distance migratory component in the population during early-mid summer indicates that this, rather than local resource tracking, constitutes a potential compensatory mechanism.

Codes: experi reach qual migrat

Bagliniere, J. L., and A. Champigneulle. 1986. Population estimates of juvenile Atlantic salmon, Salmo salar, as indices of smolt production in the R. Scorff, Brittany. Journal of Fish Biology 29: 467-482.

The numerical production of juvenile Atlantic salmon was estimated on an Armorican Massif river (Brittany), using habitat characteristics of the main stream and an annual electrofishing census from 1975 to 1983. This showed that (i) 0 + fish accounted for 79% of the production; (ii) there were larger annual variations of production in spite of some compensatory events depending on genetic and environmental factors; (iii) riffles and rapids (depth <40 cm, current velocity >40 cm s super (-1)) were the more productive habitats, providing 86.4% of the production from 28% of the water area; (iv) the middle course of the river accounted for 57.6% of production, producing more 1 + individuals in a large area of rapids. Features of this method, their limitations and the value of the results are discussed in relation to the estimation of smolt production. (DBO).

Codes: habitat quant instream temporal

Baigun, C. R., J. Sedell, and G. Reeves. 2000. Influence of water temperature in use of deep pools by summer steelhead in Steamboat Creek, Oregon (USA). Journal of Freshwater Ecology 15: 269-279.

This study examined use of deep pools (>0.8 m mean depth) based on thermal characteristics by adult summer steelhead in Steamboat Creek, Oregon. Steamboat Creek had a heterogenous thermal profile, with some segments exceeding the preferred temperature of steelhead. Deep pools were scarce (4% of the total habitat types), and 39% of them were identified as cool pools (mean bottom water temperature 19 degree C). Adult summer steelhead were found primarily in deep pools, avoiding other habitats such as glides, riffles, and even cool tributary junctions. Adult abundance in deep pools did not show significant variation between years and was inversely associated with mean bottom temperature. Use of cool pools was estimated to be 11 times the use of warm pools. However, the presence of unoccupied cool pools suggested that other ecological variables may be involved in pool selection.

Codes: habitat qual instream wtemp

Baran, P., M. Delacoste, F. Dauba, J. M. Lascaux, and A. Belaud. 1995. Effects of reduced flow on brown trout (Salmo trutta L.) populations downstream dams in French Pyrenees. Regulated Rivers: Research & Management 10: 347-361.

The effects of 16 hydroelectric power plants, in operation for 75 years, were studied in 15 non-polluted Salmonid streams in the Pyrenean mountains. The populations of brown trout (Salmo trutta L.) and the physical habitat characteristics were compared between two sections, one upstream of the dams (control section) and one below the dams with constant reduced flow (residual section). The average velocity, depth and area of cover decreased significantly below the dams. Similarly, the total abundance of brown trout calculated per linear metre of stream decreased at nine sites for biomass and eight sites for densities. The reductions of biomass and densities per unit area were less at seven sites. The abundances of the main stages of brown trout were modified differently; adults were affected more than fry by constant reduced flow. The modifications of biomass and densities of the age classes were significantly related to the instream flow below the dam, expressed as a proportion of the mean annual flow at the control section. Similarly, the differences of total, adult, juvenile and fry abundances between the control and residual section were significantly related to the differences in weighted usable area (WUA), average depth, average velocity and area of cover. A multiple linear regression model using differences of WUA and area of cover explained 84% of the difference of biomass per linear metre of stream and 68% of the difference of density. Estimating the relative capacity of a stream to support fish after a reduction in flow by measuring the variations of WUA is a promising approach for predicting the development of brown trout populations. The results are discussed in terms of modifications and the relative capacity of a stream to support a brown trout population.

Codes: multi experi reach microhab quant instream lakehydro hem

Baran, P., M. Delacoste, J. M. Lascaux, and A. Belaud. 1993. Relationships between habitat features and brown trouts populations (Salmo trutta L.) in Neste d'AureValley. Edited by J. P. Grandmottet, J. P. Masson, G. Balvay and J. Verneaux. 321-340 p.

The relationships between habitat features and biomass and density of brown trout (Salmo trutta L.) were studied in 33 sections of the Neste d'Aure stream and three of its tributaries: the Neste du Louron, the Neste du Rioumajou and the Espiaube stream in the Hautes-Pyrenees region. The Habitat Quality Index (HQI) model I (BINNS and EISERMAN, 1979), based on 10 environmental variables, was tested. The biomass predicted by the model were not linearly related with biomass of trout observed by electrofishing on the 33 sections. The best linear model was obtained after logarithmic transformations of the two variables. However, the slope of the regression line was significantly different from 1 ($t=2.53$ ($p<0.01$)). The HQI model did not appear to be a good method of assessing the biomass of brown trout in the Neste d'Aure valley. Correlations between habitat variables and brown trout biomass and density were investigated. Total biomass was significantly related to elevation (between 1350 and 600 m), cover, maximum summer temperature (between 10 and 16 degree C), conductivity, mean bottom velocity, mean depth and width/depth ratio. Total density was significantly related to the same variables, with the exception of mean depth, and in addition to water gradient and stream width. The study by age-class showed that the abundance of young-of-the-year trout is related to elevation, temperature and conductivity. Only width was the habitat feature related to abundance of young-of-the-year. No correlations were found with other physical habitat features. Abundance of one-year-old trout (1+) was related with the same variables of elevation, temperature and conductivity in addition; their density and biomass were also related to cover. Density of catchable trouts (length greater than 180 mm) was correlated with cover, depth, temperature, elevation and conductivity. The stepwise regression analyses produced combinations of variables that explained 86% of the variations in biomass (with 5 variables). This type of work can be very useful in the management of fishing and of trout populations.

Codes: multi habitat quant warning instream wtemp hem foreign

Baran, P., M. Delacoste, J. M. Lascaux, F. Dauba, and G. Segura. 1995. The interspecific competition between brown trout (Salmo trutta L.) and rainbow trout (Oncorhynchus mykiss Walbaum): Influence on habitat models. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 283-290 p.

The influence of interspecific competition on the occupation of physical habitat of the Estibere stream was studied in two rainbow trout populations (Oncorhynchus mykiss), one in allopatry and the other in sympatry with brown trout (Salmo trutta L.). The occupation of the Weighted Usable Area (WUA) was calculated by the PHABSIM model of the IFIM methodology (BOVEE, 1982). The occupation by rainbow trouts was significantly greater (t test, $p<0.05$) for the allopatric population than for the sympatric population. Surface of cover, gradient and the occupation of the physical habitat by adults of brown trout explained 77 % of the variation of the occupation of the physical habitat by rainbow trout. For the adults of brown trout, the surface of cover explained 81 % of the variation of the occupation of physical habitat. Interspecific competition may influence the occupation of physical habitat by the different species and life-stages.

Codes: microhab quant ifim sppinter instream hem foreign

Baran, P., M. Delacoste, G. Poizat, J. M. Lascaux, S. Lek, and A. Belaud. 1995. Multi-scales approach of the relationships between brown trout (Salmo trutta L.) populations and habitat features in the central Pyrenees. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 399-406 p.

The influence of spatial scales, of reach, of sequence and morphodynamic units on occupation by trout populations of the physical habitat calculatedby IFIM methodology was studied on 264 morphodynamic units of 15 streams of the Central Pyrenees (France). A variance analysis model explained respectively 51.1% and 69.8 % of the variability of the occupation of physical habitat by total density and by total biomass of trout. The results are discussed in relation to the interest of multi-scales approach for the carrying capacity concept of salmonid streams and the relation between biological processes and spatial scales.

Codes: multi microhab reach quant ifim hem foreign

Baran, P., S. Lek, M. Delacoste, and A. Belaud. 1996. Stochastic models that predict trout population density or biomass on a mesohabitat scale. Hydrobiologia 337: 1-9.

Neural networks and multiple linear regression models of the abundance of brown trout (Salmo trutta L.) on the mesohabitat scale were developed from combinations of physical habitat variables in 220 channel morphodynamic units (pools, riffles, runs, etc.) of 11 different streams in the central Pyrenean mountains. For all the 220 morphodynamic units, the determination coefficients obtained between the estimated and observed values of density or biomass were significantly higher for the neural network (r super(2) adjusted = 0.93 and r super(2) adjusted = 0.92 ($p<0.01$) for biomass and density respectively with the neural network, against r super(2) adjusted = 0.69 ($p<0.01$) and r super(2) adjusted = 0.54 ($p<0.01$) with multiple linear regression). Validation of the multivariate models and learning of the neural network developed from 165 randomly chosen channel morphodynamic units, was tested on the 55 other channel morphodynamic units. This showed that the biomass and density estimated by both methods were significantly related to the observed biomass and density. Determination coefficients were significantly higher for the neural network (r super(2) adjusted = 0.72 ($p<0.01$) and 0.81 ($p<0.01$) for biomass and density respectively) than for the multiple regression model (r super(2) adjusted = 0.59 and r super(2) adjusted = 0.37 for biomass and density respectively). The present study shows the advantages of the backpropagation procedure with neural networks over multiple linear regression analysis, at least in the field of stochastic salmonid ecology.

Codes: multi microhab quant modeling instream

Barnard, S., and R. J. Wyatt. 1995. An analysis of predictive models for stream salmonid populations. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 365-373 p.

A total of 73 multivariate (empirical) models predicting salmonid populations from biological and environmental variables were assessed. In conjunction with this, the published results of 15 tests of models are briefly commented on. The relationships between the sources of the significant variables and the performance of the models are discussed in relation to the development of HABSCORE, a management tool for salmonid fisheries which is based on empirical predictive models. An assessment of the predictive capabilities of the models implied that a combination of variables (those which relate to the large-scale features of the catch ment and those which describe the instream conditions) were more useful in predicting trout stocks than either source of variables alone. Whilst raw data gathered from relatively 'narrow' ecological ranges have been used to formulate the majority of models detailed in the literature, such models often have high predictive power only within the same ecological range, and are consequently restricted in their applicability elsewhere. In order to develop models which can be used as fisheries management tools it is desirable to base the model development on data from a wide geographical base. Although specific definitions of many parameters may differ between fishery workers, there is general agreement regarding the nature of those parameters perceived to be useful or important for model development. Given the production of a se ries of rigorous definitions for these parameters it should be possible to propose a system of habitat description that would be both widely applicable and would give rise to reproducible results.

Codes: review multi reach quant instream lulc hem

Barnard, S., R. J. Wyatt, and N. J. Milner. 1995. The development of habitat models for stream salmonids and their application to fisheries management. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 375-385 p.

The paper briefly describes the development of HABSCORE, a salmonid habitat assessment technique based on a series of empirical statistical models which relate salmonid abundance to observed habitat variables. Fisheries and habitat data for 602 notionally pristine sites throughout England and Wales were used in the development of salmonid population prediction models. These sites provided a total of 130 independent variables from which five regression models, predicting salmonid population size, were produced. These models (for 0 super (+) salmon, >0 super (+) salmon, 0 super(+) trout, >0 super(+) [<20cm] trout and >0 super(+) [>20cm] trout) explained between 28.7 % and 46.2 % of the total variance in population densities observed in the raw data. Partitioning of the variances within the raw data suggested that the models account for between 45.1 % and 86.7 % of the total spatial variation. Error associated with the measurement of the habitat variables used accounted for c1.1 % of the total variance in the five models. The quality of the models is briefly discussed. The outputs of the models, and the potential management applications of HABSCORE, are described.

Codes: multi reach quant instream lulc temporal hem

Bartholow, J. M. 1996. Sensitivity of a salmon population model to alternative formulations and initial conditions. Ecological Modelling 88: 215-236.

Salmon populations in many Pacific coast rivers are in serious decline and in danger of becoming threatened or endangered. A fish population model (SALMOD) that tracks fall chinook salmon (Orcorhynchus tshawytscha) has been developed for the Trinity River, California. The model considers the principal environmental factors influencing movement and mortality of young-of-the-year salmon from the time of spawning and egg deposition until they leave freshwater rivers as juveniles. Numbers of salmon produced by alternative managed flow regimes can be estimated using SALMOD. This paper explores the consequences of alternative model construction and formulation choices on model behavior, and the impact of the number of spawhets returning from the ocean on development of a robust flow management decision. Results show that SALMOD is responsive to the user's choice of spawner nesting behavior (superimposition), but relatively insensitive to spatial scale describing fish rearing habitat quality. The choice of a suitable managed flow regime is sensitive to the number of adult fish returning to spawn and even more so to their distribution throughout the study area at time of spawning. It would be possible to tailor an adaptive annual flow regime based on monitoring of spawner numbers and their distribution.

Codes: modeling popdyn hydro

Barton, D. R., W. D. Taylor, and R. M. Biette. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. North American Journal of Fisheries Management 5: 364-378.

The relationships between riparian land use and environmental parameters that define the suitability of southern Ontario streams for trout were examined for 40 sites on 38 streams. Weekly observations of maximum and minimum temperature, coarse and fine suspended matter, and discharge were made during June, July, and August 1980. Land use was determined from aerial photographs of each stream. Fish were surveyed at each site during August by electrofishing and seining. The only environmental variable which clearly distinguished between trout and nontrout streams was weekly maximum water temperature: streams with trimean weekly maxima less than 22 C had trout; warmer streams had, at best, only marginal trout populations. Trout streams tended to have low concentrations of fine suspended solids and a more stable discharge, but so did many of the other streams. Water temperature, concentration of fine particulate matter, and variability of discharge were inversely related to the fraction of the upstream banks covered by forest. Fifty-six percent of the observed variation in weekly maximum water temperature could be explained by the fraction of bank forested within 2.5 km upstream of a site. Other land uses were not clearly related to stream variables, except that high concentrations of fine suspended solids were most often observed in reaches used as pasture. Analysis of data from sites located within buffer strips yielded a regression relating maximum weekly temperatures to buffer strip length and width. The regression accounted for 90% of the observed variation in water temperature for these sites. The model was verified further by comparisons with observed temperatures at a second set of sites located downstream from buffer strips.

Codes: multi reach quant wtemp ripar

Bates, D. J., G. G. McBain, and R. W. Newbury. 1997. Restoration of a channelized salmonid stream, Oullette Creek, British Columbia. Edited by J. D. Hall, P. A. Bisson and R. E. Gresswell. American Fisheries Society, Oregon Chapter, Corvallis, Oregon (USA)

Oullette Creek, a second-order coastal stream, is located on the Sechelt Peninsula approximately 20 kilometers from Vancouver, British Columbia. This stream, which once supported thriving populations of anadromous salmonids, was relocated and channelized in 1978. This action resulted in major changes in stream geometry that affected fish habitat. In 1993 and 1994, detailed biophysical inventories were conducted on the lower reach of Oullette Creek. These inventories were followed by redesign and restoration of fish habitat. The primary goal of the restoration was to restore the natural pool and riffle ratio with instream rock weirs built to duplicate natural riffles and pools. The result has been the collection of spawning gravel on the upstream edge of riffles and increased areas in pools for rearing. The natural geometry of a stream of this size in this region was used to set the design width, depth, substrate size, and final pool/riffle sequencing. Basic stream characteristics of bankfull width, depth, and discharge were established by surveying a series of reaches in different tributaries in the project stream and similar drainage basins located nearby. In 1995, after the first phase of the restoration was completed, a third biophysical inventory was conducted on Oullette Creek. Preliminary results indicate that the restored areas are stabilizing, providing a significant increase in rearing habitat for both coho salmon and cutthroat trout.

Codes: experi habitat instream nofish

Baxter, C. V., C. A. Frissell, and F. R. Hauer. 1999. Geomorphology, Logging Roads, and the Distribution of Bull Trout Spawning in a Forested River Basin: Implications for Management and Conservation. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 128: 854-867.

The Swan Basin in Montana is considered a stronghold of regional significance for the bull trout Salvelinus confluentus, a native char whose populations are fragmented and declining throughout its range. We used correlation analysis to examine spatial and temporal variation of bull trout redd count data (1982-1995) relative to geomorphic and land-use factors among nine principal spawning tributaries of the Swan River. Bull trout redd numbers were positively correlated with the extent of alluvial valley segments bounded by knickpoints and negatively correlated with the density of logging roads in spawning tributary catchments. The density of logging roads in spawning tributary catchments was not significantly correlated with geomorphic factors. Temporal trends among the principal spawning streams were variable. In four of the nine principal spawning streams, redd numbers increased significantly during the survey period, and in the remaining streams, redd numbers showed no significant change. Changes in redd numbers with time were negatively correlated with catchment road density and positively correlated with the extent of bounded alluvial valley segments. The significance of bounded alluvial valley segments to bull trout spawning habitat may be related to groundwater-surface water exchange occurring within these segments. Our results emphasize the importance of valley geomorphology to bull trout, and our results suggest that prior land use may have adversely affected bull trout populations in the Swan Basin. Protection of critical spawning tributary catchments from additional road building and associated land-use disturbance will likely be necessary for the maintenance of viable bull trout populations in the Swan Basin. Geomorphic context and land-use status of spawning tributaries are important considerations for future monitoring and management of this species.

Codes: reach spawn instream wtemp substrate lulc temporal

Baxter, C. V., and F. R. Hauer. 2000. Geomorphology, hyporheic exchange, and selection of spawning habitat by bull trout (Salvelinus confluentus). Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 1470-1481.

The distribution and abundance of bull trout (Salvelinus confluentus) spawning were affected by geomorphology and hyporheic groundwater - stream water exchange across multiple spatial scales in streams of the Swan River basin, northwestern Montana. Among spawning tributary streams, the abundance of bull trout redds increased with increased area of alluvial valley segments that were longitudinally confined by geomorphic knickpoints. Among all valley segment types, bull trout redds were primarily found in these bounded alluvial valley segments, which possessed complex patterns of hyporheic exchange and extensive upwelling zones. Bull trout used stream reaches for spawning that were strongly influenced by upwelling. However, within these selected reaches, bull trout redds were primarily located in transitional bedforms that possessed strong localized downwelling and high intragravel flow rates. The changing relationship of spawning habitat selection, in which bull trout selected upwelling zones at one spatial scale and downwelling zones at another spatial scale, emphasizes the importance of considering multiple spatial scales within a hierarchical geomorphic context when considering the ecology of this species or plans for bull trout conservation and restoration.

Codes: reach quant instream substrate wtemp lulc

Baxter, J. S., and J. D. McPhail. 1997. Diel microhabitat preferences of juvenile bull trout in an artificial stream channel. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 17: 975-980.

We measured day and night microhabitat preferences of age-1 juvenile bull trout Salvelinus confluentus in an artificial stream channel in early spring, and observed a significant diel shift in both microhabitat use and preference. Microhabitat variables examined were water depth, stream bottom water velocity, overhead cover, and substrate. Fish showed a stronger preference for cover during the day than at night, and generally preferred the deeper and faster areas in the channel at night compared to the daytime. The results are of importance in determining how juvenile bull trout use cover, and they suggest that maintaining or increasing rearing capacity and survival of juveniles is related to ensuring that adequate amounts of large, coarse rock substrate remain in streams. Our observations also suggest that daytime snorkeling counts of juvenile bull trout may provide inaccurate estimates of abundance because of the juvenile's extensive use of cover during the day.

Codes: experi enclos microhab quant warning

Baxter, J. S., and J. D. McPhail. 1999. The influence of redd site selection, groundwater upwelling, and over-winter incubation temperature on survival of bulltrout (Salvelinus confluentus) from egg to alevin. Canadian Journal of Zoology/Revue Canadien de Zoologie [Can. J. Zool./Rev. Can. Zool.] 77: 1233-1239.

We measured survival of bull trout (Salvelinus confluentus) embryos to the alevin stage in areas selected and not selected by females for spawning. In this study we tested the hypotheses that (1) females are utilizing habitats influenced by discharging groundwater and that (2) there is a reproductive advantage to spawning at these selected sites. Embryo survival was assessed by placing fertilized eggs in capsules that could be retrieved once they were placed in selected and nonselected locations. The survival rate was significantly higher (88.6 vs. 76.1%) and less variable in the selected area, but alevin lengths did not differ significantly between areas. The selected areas were, on average, locations of groundwater discharge and higher water temperatures over the incubation period, while nonselected locations were in areas of surface-water recharge and lower water temperatures. The results suggest that appropriate reproductive habitats which offer the best incubation environments may be limited in bull trout systems, and that site selection by females may increase fitness and be critical for population viability.

Codes: microhab popdyn spawn hydro wtemp

Beall, E., J. Dumas, D. Claireaux, L. Barriere, and C. Marty. 1994. Dispersal patterns and survival of Atlantic salmon (Salmo salar L.) juveniles in a nursery stream. ICES Journal of Marine Science 51: 1-9.

The spatial and temporal patterns of dispersal and the survival of Atlantic salmon (Salmo salar L.) fry and parr were analysed over 1 year in a small stream of the Basque Country (south-west France). Dispersal just after emergence was studied with eight drift nets placed 10 to 800 m downstream from an artificial redd stocked with 15 000 eyed eggs. Subsequent distribution of parr was determined by electrofishing in June, October, and February in representative sections of the stream including habitats 750 m upstream and 2400 m downstream from the redd. Early dispersal following emergence lasted 12 days for the majority (95%) of the fry population. Most fry (71%) settled within the first 200 m downstream from the redd, and 91% within the first 400 m. In June, parr were found 2400 m downstream and 750 m upstream, with 68% of the population established within 900 m downstream, and only 4% upstream. In October, there was a slight downstream shift of densities. In February, 56% of the parr were found within 900 m downstream and 11% upstream. Survival from egg planting to first dispersal in March was 51.9% and 11.8% over 1 year.

Codes: reach spawn quant popdyn migrat

Beard, T. D., Jr., and R. F. Carline. 1991. Influence of spawning and other stream habitat features on spatial variability of wild brown trout. Transactions of the American Fisheries Society 120: 711-722.

Total densities of wild brown trout Salmo trutta ages 1 to 7 varied widely (range, 130-1,304/hectare) among 12 sample sections in Spring Creek, a 35-km-long stream in a limestone area of central Pennsylvania. During a 2-year study we determined the relative importance of spawning habitat and other habitat features on spatial variation in density. Densities of age-0 and of all age-1 and older brown trout were positively correlated with redd densities. Embryo survival was lowest in sections with low brown trout densities, but embryo survival was not as important as redd density in determining population size. Redd density appeared to be a function of availability of suitable spawning substrate. Habitat variables such as depth, pool area, cover, and substrate were not correlated with brown trout density. Spawning habitat and other habitat features were quantified with the habitat suitability index model. Scores derived from the model were poorly correlated with densities of age-0 and of age-1 and older brown trout.

We concluded that juvenile brown trout do not disperse widely from natal areas, and that local population densities are largely a function of the availability of spawning habitat.

Codes: reach quant popdyn spawn instream ifim warning hem

Beecher, H. A., T. H. Johnson, and J. P. Carleton. 1993. Predicting microdistributions of steelhead (Oncorhynchus mykiss) parr from depth and velocity preference criteria: test of an assumption of the Instream Flow Incremental Methodology. Canadian Journal of Fisheries and Aquatic Sciences 50: 2380-2387.

We tested an assumption of the Physical Habitat Simulation of the Instream Flow Incremental Methodology (IFIM) that fish select microhabitats based on the quality of one or several hydraulic conditions. We developed preference curves for juvenile steelhead (Oncorhynchus mykiss) in Morse Creek, Washington, USA, that accounted for availability of depths and velocities and their utilization by steelhead parr. To allow comparison of intervals among preference curves from different studies, we developed preference indices. We then evaluated the relationship between steelhead parr density and preference or preference indices for depth, velocity, and depth and velocity combined using an independent data set from a different year and an adjacent location in Morse Creek; these indices reflected observed densities of steelhead parr. There was a significant rank correlation between steelhead parr density and preferences or preference indices of steelhead parr for velocity alone and for depth and velocity combined, but not for depth alone. Steelhead parr strongly avoided habitat in which depth preference was 0.0, but velocity preference appeared to influence use of habitat where depth preference was not 0.0. Steelhead parr avoided cells with low preference indices and preferred cells with high preference indices. These relationships support an assumption of the IFIM.

Codes: quant microhab ifim hem

Behmer, D. J., and C. P. Hawkins. 1986. Effects of Overhead Canopy on Macroinvertebrate Production in a Utah Stream. Freshwater Biology 16: 287-300.

Fish managers often recommend removal of riparian trees and shrubs along trout streams to increase sun-light penetration and allow increased growth of algae and aquatic macrophytes within the stream. The enhanced plant growth is assumed to increase stream productivity by increasing the base of the food chain and preventing fine sediments from shifting over gravel and rubble. Macroinvertebrate abundance and production were compared between an open and shaded site of a stream in the Wasatch Mountains, Utah. Mean biomass was significantly higher at the open site for midges (Chironomidae), 4.6 times; Baetis bicaudatus, 5.7 times; Baetis tricaudatus, 2.3 times; Drunella coloradensis, 12 times and Cinygmula sp., 1.6 times. Abundance of most other macroinvertebrates (except black flies: Simuliidae) was also greater at the open site, but differences were not significant. Black fly biomass was 1.7 times greater at the shaded site. Seasonal production, estimated by the size-frequency and instantaneous growth rate methods, was greater at the open site than the shaded site for most taxa (except black flies) and reflected differences in standing crops between the sites rather than differences in rate of growth. Excluding black flies, production at the open site was twice as high as at the shaded site. The greater abundance and production of most invertebrate taxa at the open site is probably associated with either higher quality food (algae and algal detritus), or a phototactic attraction to sunlit areas. Sampling of large cobbles was an efficient method of sampling all taxa except Cinygmula sp. which was more abundant on smaller substrate particles.

Codes: experi reach nofish ripar

Bergheim, A., and T. Hesthagen. 1990. Production of juvenile Atlantic salmon, Salmo salar L., and brown trout, Salmo trutta L., within different sections of a small enriched Norwegian river. Journal of Fish Biology 36: 545-562.

Growth, density and production of juvenile Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) were studied in three different sections of the Kvassheimsaana River in south-western Norway from 1979 to 1983. Section 1, in the upper part of the river, is located above a waterfall impassable for migratory salmonids and is surrounded by grazing land. Sections 2 and 3, in the middle and lower parts of the river, are influenced by agricultural activity. The number of 0+ salmon sections 2 and 3 varied between 30 multiplied by 1 and 167 multiplied by 8 specimens 100 m super (-2), with mean values of 90 multiplied by 2 and 95 multiplied by 2 specimens 100 m super (-2), respectively; the density of 1+ salmon, with mean values of 16 multiplied by 3 and 51 multiplied by 0 specimens 100 m super (-2), was significantly correlated with the original fry density. Densities of brown trout were low in all sections (< 20 specimens 100 m super (-2)). Fry density was highest in section 3 and parr density in section 1. All age groups of sympatric brown trout grew significantly faster in sections 2 and 3 compared with allopatric brown trout in section 1.

Codes: reach experi graz ag quant

Biggs, B. J. F., M. J. Duncan, I. G. Jowett, J. M. Quinn, C. W. Hickey, R. J. Davies-Colley, and M. E. Close. 1990. Ecological characterisation, classification, and modelling of New Zealand rivers: An introduction and synthesis. New Zealand Journal of Marine and Freshwater Research 24: 277-304.

A programme of research to characterise, classify, and model New Zealand rivers according to hydrological, water quality, and biological properties is introduced. The results are detailed in the accompanying eight research papers. These studies provide the first national perspective on water quality and biology in New Zealand's rivers using a consistent methodology. They are also the first step toward providing managers with robust models for predicting the effects on aquatic biota of changes in flow regimes and catchment land use. A synthesis of the results is given in this paper together with recommendations for riverine ecoregions in New Zealand. #(See Jowet 1992)#.

Codes: multi quant datasource modeling instream lulc hydro

Bilby, R. E., and P. A. Bisson. 1987. Emigration and production of hatchery coho salmon (Oncorhynchus kisutch) stocked in streams draining an old-growth and clear-cut watershed. Canadian Journal of Fisheries and Aquatic Sciences 44: 1397-1407.

Downstream movement of coho salmon fry (Oncorhynchus kisutch) stocked in old-growth and clear-cut watersheds occurred in three phases: (1) a brief period of heavy emigration immediately after stocking, (2) relatively little movement throughout most of the summer, and (3) intermittent heavy emigration during early autumn freshets. Coho emigrated whenever a streamflow change greater than or equal to 3% multiplied by d super (-1) occurred, but movement nearly ceased at flows above a certain level. Temperature changes were less important than discharge in triggering movement. When high densities were stocked, emigrant fry were smaller than residents. Coho production therefore appeared to be most strongly influenced by trophic conditions, while volitional residency was most strongly influenced by habitat quality.

Codes: multi reach qual migrat hydro

Bilby, R. E., and B. R. Fransen. 1992. Effect of habitat enhancement and canopy removal on the fish community of a headwater stream. Northwest Science 66: 137.

The riparian trees along a 2km section of stream in western Oregon were logged in 1985, in violation of forest practice regulations. As part of the judgement against the landowner, wood was placed in the channel to improve habitat in 1988. Fish populations and habitat have been monitored since 1986 at 3 sites: the enhanced area, an non-enhanced reach without a canopy and a non-enhanced reach with a canopy. Pool area increased 20% as a result of the wood addition at the enhanced site. Pool area during summer also increased at the site with the canopy due to beaver activity. Speckled dace (Rhinichthys osculus) have exhibited the greatest response, increasing in numbers at all 3 sites, with greatest gains in the enhanced reach. Salmonid density at all three sites also has increased since 1988. Age 0+ steelhead (Oncorhynchus mykiss) exhibit an inverse relationship between density and growth.

Codes: experi reach quant ripar instream

Bilby, R. E., B. R. Fransen, and P. A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53: 164-173.

Epilithic organic matter, all aquatic macroinvertebrates except shredders, and fish were significantly enriched with N and C in streams (western Washington state, U.S.A.) where spawning coho salmon (Oncorhynchus kisutch) were present. Riparian vegetation adjacent to salmon-bearing streams and shredding macroinvertebrates were enriched with N but not C. The highest levels of enrichment of the stream biota with the heavier isotopes occurred in the early spring, shortly after carcasses had decomposed. Autotrophic uptake was not an important avenue of incorporation. The proportion of nitrogen contributed by spawning salmon varied among trophic categories, ranging from about 17% in collector-gatherers to more than 30% in juvenile coho salmon. Carbon contributed by spawning ranged from 0% in the foliage of riparian plants and shredders to 34% in juvenile coho salmon.

Codes: multi reach qual ripar trophic

Binns, N. A. 1994. Long-term responses of trout and macrohabitats to habitat management in a Wyoming headwater stream. North American Journal of Fisheries Management 14: 87-98.

After 111 habitat improvement devices and 2,150 ft of riprap were installed (1973-1977) in Beaver Creek, northeast Wyoming, the stream developed a narrower channel with deep pools that helped brook trout Salvelinus fontinalis survive low flows. After 7 years, brook trout 6 in and longer had increased 1,814%, brook trout less than 6 inches had increased 1,462%, and the total population density had reached 2,074/mi (268 lb/acre). By 1990, after extended drought during the 1980s, the brook trout population had dropped to 222/mi (41 lb/acre), but this level was 90% better than before habitat development. Over 90% of the devices remained fully functional 18 years after installation, even though some of them were esthetically displeasing due to exposure of logs and planks. Wooden plunges were comparatively easy to install and dug good pools. Deflectors worked better directing currents than digging pools. Wood bank overhangs and overpour (Hewitt) ramps provided variable results, were hard to install, were apt to be damaged by floods, and are not recommended for Wyoming streams.

Codes: experi reach habitat quant hydro temporal

Binns, N. A., and F. M. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Trans. Am. Fish. Soc. 108: 215-228.

A habitat quality index (HQI) was developed to predict trout standing crop in Wyoming streams. Measurements of trout habitat were collected from 36 streams that ranged in elevation from 1,146 to 3,042 m. Average late summer stream width varied from 1.4 to 44 m, while average daily flow was between 0.6 and 1.46 mSUP-3 /second. Stream gradient ranged from 0.1% to 10%. A multiple regression analysis indicated those habitat measurements best related to trout standing crop in the study streams. Predictive models were built from these measurements. The best HQI model explained 96% of the variation in trout standing crop (multiple regression correlation coefficient $R = 0.983$), suggesting a close relationship between HQI predictions and measured trout stocks. The nine habitat attributes used in this model were late summer stream flows, annual stream flow variation, water velocity, trout cover, stream width, eroding stream banks, stream substrate, nitrate nitrogen concentration, and maximum summer stream temperature.

Codes: multi habitat quant instream substrate wtemp hem

Binns, N. A., and R. Remmick. 1994. Response of Bonneville cutthroat trout and their habitat to drainage-wide habitat management at Huff Creek, Wyoming. North American Journal of Fisheries Management 14: 669-680.

Beginning in 1978, in an effort to restore Bonneville cutthroat trout Oncorhynchus clarki utah, 68 instream habitat structures and 3,760 ft of rock riprap were installed in the Huff Creek (Wyoming) drainage, and livestock was controlled through exclosures and herding. Drainage-wide cutthroat trout abundance and biomass peaked in 1984 at 456 trout/mi and 56 lb/acre. The largest population (1984; 685 trout/mi, 82 lb/acre) occurred at the site containing instream structures within an exclosure. By 1989, mean cutthroat trout numbers (170 trout/mi) were significantly higher ($P = 0.01$) than in 1978 (35 trout/mi), despite severe drought in 1987-1989 and a 75-100 year flood in 1984. Drainage-wide Habitat Quality Index scores were significantly higher and total cover was significantly greater in 1989 than in 1978, but bank stability was not significantly improved. However, banks armored with machine-placed rocks became stable; in contrast, natural healing was slow where rocks were not used. Cutthroat trout abundance was correlated to the previous year's stream discharge, the quantity of cover, and pool area. Plunge pools created by instream structures were deeper than natural pools and greatly aided fishery rejuvenation.

Codes: experi reach habitat quant graz hydro temporal

Bjornn, T., and D. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138. In The influence of forest and rangeland management on salmonids and their habitat. W. R. Meehan, editors. American Fisheries Society Special Publication 19, Bethesda, MD.

#excellent review. Good source for spawning and juvenile habitat preferences and survival at habitat scales, inc. lab work. Good summary of WUA and varibility, with dependence on pref. curves presumed (p124-5).#.

Codes: review habitat quant spawn instream watqual wtemp

Bjornn, T. C., S. C. Kirking, and W. R. Meehan. 1991. Relation of cover alterations to the summer standing crop of young salmonids in small southeast Alaska streams. Transactions of the American Fisheries Society 120: 562-570.

Summer abundance of young coho salmon Oncorhynchus kisutch, steelhead O. mykiss, and Dolly Varden Salvelinus malma was assessed in small streams on Prince of Wales Island, Alaska, in an attempt to measure the response of these fish to various types of cover alterations. The standing crop of subyearlings decreased during summer, but none of the decrease could be attributed to the changes in cover we made. Subyearling coho salmon (about 75% of the fish present) did not respond either to the removal of natural riparian vegetation or to the addition of simulated riparian canopy, large boulders, woody debris, or simulated undercut banks. Localized movements within the streams were sufficient to provide relatively rapid recolonization of the experimental habitat units. The forms of cover we evaluated were relatively unimportant in regulating abundance of young coho salmon in small streams.

Codes: experi multi habitat quant migrat ripar

Black, R. W., and T. A. Crowl. 1995. Effects of instream woody debris and complexity on the aquatic community in a high mountain, desert stream community. Edited by D. A. Hendrickson.

In order to understand the effect of changes in habitat complexity generated by instream woody debris on trout and macroinvertebrate densities and their interactions, we manipulated woody debris densities in the fall of 1991, resulting in significant changes in trout densities and physical characteristics in the summer of 1992. Trout prey electivity (Chesson's) and capture efficiency were directly related to habitat complexity. Macroinvertebrate densities did not respond as significantly to changes in habitat complexity as trout densities. The macroinvertebrates appeared to be limited by primary productivity rather than habitat complexity at the scale of complexity examined here. Habitat complexity was decreased in all of the manipulated study sections by high spring runoff in 1993 which removed most of the smallest branches. Measured responses where not as significant due to the reduction in complexity caused by high spring runoff. If stream restoration efforts are to succeed, additional work on spatial and temporal changes in habitat complexity are needed.

Codes: experi reach quant instream lwd trophic

Blackwell, B. F., G. Gries, F. Juanes, K. D. Friedland, L. W. Stolte, and J. F. McKeon. 1998. Simulating migration mortality of atlantic salmon smolts in the Merrimack River. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 18: 31-45.

Successful restoration of Atlantic salmon Salmo salar to New England rivers involves the identification and management of mortality sources at different life history stages. The purpose of this study was to examine the effects of mortality during migration on Atlantic salmon smolts exiting the Merrimack River. Our objective was to review data pertaining to smolt production, migration, passage at hydroelectric facilities, and predation in the Merrimack River and construct a simulation model of smolt migration. We constructed a migration model incorporating riverflow-based decision rules affecting migration rate, delay at dams, dam passage mortality, and migration mortality. Mean model estimates of in-river survival ranged from 0.7% to 23.5%. Estimated transit times generally increased in migration scenarios in which smolts began migration later in the season; beginning migration later in the season also resulted in lower in-river survival. The model was evaluated by comparing records of returns of two-seawinter adults to the Merrimack River to a likely range of marine survival rates. For 9 of 14 smolt years, model estimates for the number of smolts exiting the river were comparable with the range of smolt output necessary to achieve the corresponding adult returns. Model estimates of in-river survival that fell below the the lower threshold for 5 of the 14 smolt years could be explained in part by relatively high marine survival experienced by these cohorts. We argue that this model can have important applications in population assessment, river management, and salmon restoration.

Codes: modeling migrat popdyn noenv hydro

Bohlin, T. 1977. Habitat selection and intercohort competition of juvenile sea-trout Salmo trutta. Oikos 29: 112-117.

By artificially changing the population density, the habitat preference of 1+ sea-trout S. trutta with respect to different biotopes was studied by electro-fishing in a closed area of of a small stream. The trout seemed to prefer pools or rocky substrates to shallow, smooth-bottom riffles. Marking experiments supported the hypothesis of 'owner's advantage' in the competition for space between resident and introduced fish, and revealed a marked stationarity in spite of possible experimental disturbances. There were significant differences between the mean lengths of 1+ trout in the different biotopes, the deeper biotopes having the largest means. A few older trout showed a similar pattern. There were significant differences between the relative density of O+ trout in the diferent biotopes, the largest densities occurring in shallow, smooth-bottom riffles with low density of older trout. Stream tank experiments showed a tendency for competitive segregation between O+ and I+ trout, the latter being dominant and preferring pools to riffles. Field data of O+ and 1+ density showed a biennial fluctuation with alternating peaks for

O+ and 1+ for a period of five consecutive years. Intercohort interaction, favoured by drought, was a probable cause.

Codes: experi habitat enclos quant instream sppinter lab

Bourgeois, C. E., D. A. Scruton, D. E. Stansbury, and J. M. Green. 1993. Preference of juvenile Atlantic salmon (Salmo salar) and brook trout (Salvelinus fontinalis) for two types of habitat improvement structures. Edited by R. J. Gibson and R. E. Cutting. 103-108 p.

A long-term research program has been developed to evaluate transferability of habitat improvement technology, developed throughout North America, for use with freshwater fish species and endemic conditions in Newfoundland. The initial experiment in this study program in 1990 was to test preferences of juvenile Atlantic salmon (Salmo salar) and brook trout (Salvelinus fontinalis) for two types of habitat improvement structures installed in a controlled flow spawning channel. Data analysis revealed no difference in preferences between species for the test structures based on volitional residence after 5 days. Both species demonstrated a similar order in preference for the mid-channel, stream bank, and control treatments, respectively. This order of selection was constant at high and low density and low and average density but not high and averge density.

Codes: experi enclose quant habitat

Bourgeois, G., R. A. Cunjak, D. Caissie, and N. El Jabi. 1996. A spatial and temporal evaluation of PHABSIM in relation to measured density of juvenile Atlantic salmon in a small stream. North American Journal of Fisheries Management 16: 154-166.

We evaluated the relationship between weighted usable area (WUA) predicted by the physical habitat simulation (PHABSIM) model and the population density of juvenile Atlantic salmon Salmo salar in Catamaran Brook, New Brunswick, Canada. Various temporal and spatial scales of study were used to establish whether a positive linear relationship existed. The PHABSIM model was applied to 19 sites representing four habitat types, and various streamflow scenarios were used to calculate the amount of available WUA. Maximum WUA values for different habitat types and different reaches usually occurred at flows representing 85% of mean annual flow. Fish densities at the 19 sites were estimated by electrofishing in the summer and late autumn for 3 years. Few positive, significant relations were established between Atlantic salmon density and WUA; r super(2) values ranged from 0.18 to 0.95, with the best relations occurring at the scale of habitat type (5 of 16 comparisons were significant, $P < 0.05$). The WUA values calculated from the 15-d average flow before fish sampling displayed the best associations with fish density. (See Cade, B. S. & Terrell, J. W. 1997 criticism of regression forced through zero).

Codes: microhab quant ifim warning hydro hem

Bowlby, J. N., and J. G. Imhof. 1989. Alternative Approaches in Predicting Trout Populations from Habitat in Streams. Pages 317-330. In Alternatives in Regulated River Management. CRC Press, Boca Raton Florida.

Trout modeling attempts have led to the development of the Ontario Trout Habitat Classification (OTHC), which is a model developed using discriminant function analyses to relate trout habitat variables to broad categories of trout biomass density. Here two models used to predict trout biomass density, the Habitat Quality Index (HQI) developed by Binns and Eiserman and the OTHC are examined, including their problems, and improvements are proposed. In the development of OTHC, variables with some nonlinearity performed better in discriminant function models than regression models. Where trout populations are stable, higher precision in prediction might be obtained and a regression model would be preferable. Otherwise, a discriminant function model might provide as much precision as a regression model. The selected variables should represent limiting habitat factors. The variables used in HQI (late summer flow index, annual flow variation, maximum summer temperature, nitrate, benthic invertebrate diversity, eroding banks, submerged aquatic vegetation, water velocity, and stream width) and OTHC (ATP concentration of suspended solids, mean July and August maximum weekly temperature, biomass of benthos, log shelter, undercut bank shelter, and pool area) are good candidates. However, care must be taken to avoid highly correlated, redundant variables. Different life stages of fish have different requirements. Accordingly, a simple regression or discriminant function model cannot be expected to provide a resource manager with a complete set of predictions required to manage fish habitat. An alternative approach may be to develop multistage models that are interdependent. Habitat could then be managed to optimize survival of the most critical life history stage. (See also W90-09997) (Rochester-PTT).

Codes: multi modeling warning instream wtemp trophic hem

Bowlby, J. N., and J. C. Roff. 1986. Trout biomass and habitat relationships in southern Ontario streams. Transactions of the American Fisheries Society 115: 503-514.

The authors examined relationships between the biomass of trout (species of Salvelinus and Salmo) and physical and biological habitat variables in streams to identify habitat factors that might limit trout biomass. Two habitat quality index models developed by Binns and Eiserman for Wyoming streams accounted for only 6.7 and 9.2% of the variation in trout biomass at Ontario stream sites. Different factors must limit trout biomass in Wyoming streams than in Ontario streams. Regression and discriminant function analyses indicated that trout biomass in southern Ontario is correlated with microcommunity biomass (measured as ATP of the suspended solids, and representing bacteria, fungi, and algae), percent pool area, mean maximum summer temperature, biomass of small benthic invertebrates, presence of piscivorous fish, and a variable representing pools and overhead cover.

Codes: multi reach quant instream wtemp trophic

Bozek, M. A. 1991. Generality of habitat models for Colorado River cutthroat trout fry and the influence of adults on habitat choice and behavior. Dissertation, University of Wyoming.

Because habitat choice by fish can be influenced by various abiotic and biotic factors, habitat models developed in streams can be site-specific and, thus, limited in their general application across streams. Macro- and microhabitat analyses provided complimentary information concerning the habitat use of cutthroat trout (Oncorhynchus clarki) fry. On a microhabitat scale, fry generally used slow water velocities (<0.06 m/s), water depths greater than 3 cm, and a variety of substrate types. Different geomorphological features provided suitable microhabitat among the study streams. On a macrohabitat scale, fry density was related to the abundance of spawning gravel. Adults appeared to have little influence on the habitat used by fry in either laboratory or field conditions primarily due to the abundance of slow-water in all cases. Habitat selection of fry appears to reflect innate preferences rather than adult-fry interactions. The generality of habitat suitability models among seven geomorphically different first- and second-order streams and among years at two of those sites was analyzed. Water depths, velocities and substrates that were available to and used by fry differed significantly among sites and years. No single model developed from any site was found to be satisfactory for use across all sites. However, use of either site-specific models or a composite model appeared to be satisfactory for predicting suitable habitat at each site. Knowing the degree of variability in model predictions prior to use can allow users to determine acceptable levels of error and base their management decisions accordingly. (DBO).

Codes: habitat microhab modeling instream substrate

Bozek, M. A., and F. J. Rahel. 1991. Assessing habitat requirements of young Colorado River cutthroat trout by use of macrohabitat and microhabitat analyses. Transactions of the American Fisheries Society 120: 571-581.

The authors used both microhabitat and macrohabitat analyses to better assess habitat requirements of young Colorado River cutthroat trout Oncorhynchus clarki pleuriticus. Microhabitat analyses revealed that among a range of stream types, young cutthroat trout consistently preferred slow water (<0.06 m/s) and depths over 3 cm. Suitable habitat of this type was provided by different types of pool habitat within the geomorphically diverse study streams.

Macrohabitat analysis indicated that the density of young cutthroat trout was positively correlated with the abundance of spawning gravel and negatively correlated with stream depth (adjusted R super(2) = 0.67). This relationship helped explain the absence of young cutthroat trout from some stream reaches that had suitable microhabitat but that often lacked suitable spawning habitat. The two types of habitat analysis provided complementary information concerning the habitat requirements of young Colorado River cutthroat trout in the study streams.

Codes: habitat microhab instream

Bozek, M. A., and F. J. Rahel. 1992. Generality of microhabitat suitability models for young Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) across sites and among years in Wyoming streams. Canadian Journal of Fisheries and Aquatic Sciences 49: 552-564.

The generality of microhabitat-use and preference models for young-of-year (YOY) Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) was tested across sites and years among geomorphically different streams. Depths, velocities, and substrate types used by YOY cutthroat trout often differed across both sites and years. These differences could only partially be explained as a result of differences in microhabitat availability. Microhabitat-use and preference models also varied in their ability to predict the amount of suitable microhabitat across sites. Estimates of suitable microhabitat abundance differed by up to 40% when microhabitat models were randomly used across sites. Use of a composite model resulted in estimates of suitable microhabitat abundance that differed by less than 20% of that estimated by site-specific models.

Codes: multi habitat microhab instream substrate warning

Bradford, M. J. 1994. Trends in the abundance of chinook salmon (Oncorhynchus tshawytscha) of the Nechako River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 51: 965-973.

Trends in the abundance of chinook salmon (Oncorhynchus tshawytscha) of the Nechako River, a tributary of the Fraser River, were analyzed to quantify the ecological effects of water abstraction for electricity generation. In years when the majority of returning chinook adults used the upper Nechako River for spawning, the survival of offspring for the entire river was poorer than in years when spawning was concentrated in the lower reaches. Relative to the historical discharge, the upper Nechako River has experienced the greatest degree of water abstraction, and the lower survival of chinook brooks originating from the upper river may be early emergence of fry caused by elevated fall and winter water temperatures or to higher rates of predation on juveniles and loss of rearing habitat caused by the elimination of the spring freshet.

Codes: popdyn hydro temporal noenv

Bradford, M. J., and P. S. Higgins. 2001. Habitat-, season-, and size-specific variation in diel activity patterns of juvenile chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss). Canadian journal of fisheries and aquatic sciences/Journal canadien des sciences halieutiques et aquatiques. Ottawa ON [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 58: 365-374.

Juvenile salmonids that live in streams are sometimes nocturnal and may spend the day concealed in the stream substrate. The diel activity patterns of juvenile chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss) were observed in two areas of the Bridge River, British Columbia, in all four seasons. In a reach with higher flows, most fish were nocturnal year-round, and they emerged from the substrate only at dusk to forage. In the reach with lower flows, some fish were active in the water column in the day in summer, but others remained concealed in the substrate until dusk. Parr and older fish were more nocturnal in summer than fry. All fish were nocturnal in winter. Because this study design controlled for temperature and photoperiod, it was concluded that the differences in behaviour that were observed between reaches were due to habitat conditions that likely affected the trade-off between more risky daytime foraging and less efficient, but safer, nighttime foraging. Habitat-driven variation in activity patterns will likely affect the processes that regulate these populations and could make the prediction of the effects of ecosystem manipulations such as changes in flow very difficult.

Codes: habitat qual migrat hydro

Bradford, M. J., and J. R. Irvine. 2000. Land use, fishing, climate change, and the decline of Thompson River, British Columbia, coho salmon. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 13-16.

This study investigates a recent, major decline in the abundance of a large aggregate of coho salmon (Onchorynchus kisutch) spawning in the Thompson River, British Columbia, watershed. It was found that the decline could be attributed to a declining trend in productivity related to changing ocean conditions, overfishing, and freshwater habitat alteration. Among individual watersheds, rates of decline in adult coho salmon abundance were correlated with agricultural land use, road density, and a qualitative measure of stream habitat status but not with the proportion of land recently logged. The recovery of these populations will require the prudent regulation of fishing, the restoration of salmon producing watersheds, and an improvement in ocean conditions.

Codes: basin quant instream lulc temporal

Bradford, M. J., R. A. Myers, and J. R. Irvine. 2000. Reference points for coho salmon (Oncorhynchus kisutch) harvest rates and escapement goals based on freshwater production. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 677-686.

A simple scheme is described for the management of coho salmon (Oncorhynchus kisutch) population aggregates that uses reference points derived from an empirical analysis of freshwater production data. A rectilinear "hockey stick" model is fit to 14 historical data sets of female spawner abundance and resulting smolt production and found that at low spawner abundance, the average productivity was about 85 smolts per female spawner. Variation in productivity among streams may be related to the quality of the stream habitat. It is shown here how freshwater productivity can be combined with forecasts of marine survival to provide a limit reference point harvest rate. The method used here will permit harvest rates to track changes in ocean productivity. Historical data was also used to estimate that, on average, a density of 19 female spawners times km super (-1) is required to fully seed freshwater habitats with juveniles. However, there was considerable variation among the streams that might limit the utility of this measure as a reference point. Uncertainty in the forecasts of marine survival and other parameters needs to be incorporated into this scheme before it can be considered a precautionary approach.

Codes: multi basin quant popdyn noenv

Bradford, M. J., and G. C. Taylor. 1997. Individual variation in dispersal behaviour of newly emerged chinook salmon (Oncorhynchus tshawytscha) from the upper Fraser River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 54: 1585-1592.

Immediately after emergence from spawning gravels, fry of stream-type chinook salmon (Oncorhynchus tshawytscha) populations from tributaries of the upper Fraser River, British Columbia, distribute themselves downstream from the spawning areas, throughout the natal stream, and into the Fraser River. The hypothesis was tested that this range in dispersal distances is caused by innate differences in nocturnal migratory tendancy among individuals. Using an experimental stream channel, repeatable differences were found in downstream movement behaviour among newly emerged chinook fry. Fish that moved downstream were larger than those that held position in the channel. The incidence of downstream movement behaviours decreased over the first 2 weeks after emergence. It was proposed that the variation among individuals in observed downstream movement behaviour leads to the dispersal of newly emerged fry throughout all available rearing habitats. Between- and within-population variation in the freshwater life history observed in these populations may be caused by small differences in the behaviour of individuals.

Codes: experi reach migrat

Bradford, M. J., G. C. Taylor, and J. A. Allan. 1997. Empirical review of coho salmon smolt abundance and the prediction of smolt production at the regional level. Transactions of the American Fisheries Society 126: 49-64.

Regional habitat and fisheries management planning requires estimates of the capacity of watersheds to produce salmonids. To predict the average abundance of smolts of coho salmon Oncorhynchus kisutch produced by streams and rivers, we related estimates of smolt abundance to habitat features derived from maps and discharge records. We assembled a database of 474 annual estimates of smolt abundance from 86 streams in western North America for this analysis. We found that only stream length and to a lesser extent latitude were useful in predicting mean smolt abundance. The frequency distribution of annual estimates of smolt abundance from individual streams tended towards a normal rather than the more usual lognormal distribution; the median coefficient of variation in abundance was 37%. Our results are consistent with the view that, on average, smolt abundance is limited by spatial habitat, but that there is significant annual variation in abundance probably due to variation in habitat quality caused by climate, flow, or other factors. We conclude that forecasting smolt yield from stream length and latitude is feasible at the watershed or regional level, but that the precision of a prediction for a single stream is poor. A more detailed approach will be required for local forecasting.

Codes: multi quant basin temporal warning

Bremset, G., and O. K. Berg. 1997. Density, size-at-age, and distribution of young Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) in deep river pools. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 54: 2827-2836.

A comparison of populations of juvenile Atlantic salmon (Salmo salar) and brown trout (S. trutta) in four deep pools (maximum depths 2.0-4.0 m) and 12 shallow riffles in three rivers showed significantly higher density, size-at-age, and biomass of the pool-dwelling salmonids. There were 2.5 times more parr per unit of area in the pools compared with the riffles. The pool-dwelling trout had a larger size-at-age than riffle specimens, and the pool-dwelling salmon were larger than those found in the riffles in three of four cases. The relative biomass of salmonid parr in two of the investigated pools was 6.9 and 12.0 g/m super(2) compared with the means of 1.6 and 3.7 g/m super(2) in the riffles. There are two possible explanations that are discussed for the larger size-at-age of the fish in the deep pools: 1) movements of large, dominant parr into the pools as they grow older or 2) favorable conditions in the pools that give pool-dwelling fish an energetic advantage. In contrast with established theory, the current data show that deep pools are favorable habitats for both young Atlantic salmon and brown trout.

Codes: multi habitat quant migrat instream

Bridcut, E. E., and P. S. Giller. 1993. Movement and site fidelity in young brown trout Salmo trutta populations in a southern Irish stream. Journal of Fish Biology 43: 889-899.

Populations of brown trout Salmo trutta were monitored at a number of sites within a single stream, using an individual marking technique and recapturing uniquely marked fish repeatedly over a period of 12 months. Individual 1+ and 2+ resident brown trout in the Glenfinish River were found to consist of stationary and mobile component populations. The latter population consisted of a number of individuals observed moving mostly in an upstream direction, within a range of 0.03-2.24 km. On a large spatial scale, individuals in the stationary component population exhibited some degree of home site fidelity within the stream, over a period of 3-4 months, after which the fish tended to move from the site. Within sites, fidelity to either riffle or pool habitats, mostly the latter, was apparent in a proportion of the population. On a smaller scale, fidelity to the exact position with respect to boulders in the stream was also evident in a number of individuals. Home range size was calculated amongst these individuals, with ranges of up to 20 m recorded.

Codes: quant migrat habitat reach instream

Brown, T. G., and G. F. Hartman. 1988. Contribution of seasonally flooded lands and minor tributaries to the production of coho salmon in Carnation Creek, British Columbia. Transactions of the American Fisheries Society 117: 546-551.

Ten percent of the juvenile coho salmon Oncorhynchus kisutch rearing in the main channel of Carnation Creek during the summer moved into intermittent tributaries and ephemeral swamps (off-channel winter habitats) during the autumn of 1983. The number of juveniles residing within specific off-channel sites during winter was governed by the magnitude of water levels associated with the first fall storms relative to the flooding levels required for adequate access to these sites ($P < 0.05$). Off-channel habitats contributed 15.3% of the watershed's coho salmon smolts in 1983 and 23.1% in 1984. A 25-year flood event (65 m^3/s) occurred in January 1984 and may have reduced the main-channel contribution for that year. The inability of coho salmon smolts to emigrate from off-channel habitats and return to the main channel in spring may have reduced the off-channel contribution in 1983. April-May water levels were 37% below the 13-year mean water level in 1983 and 55% above it in 1984.

Codes: quant offchann hydro

Brown, T. G., I. V. Williams, and A. Langston. 1987. Watershed database: Barkley Sound, Vancouver Island. Report ISSN 0706-6465. database.

Catalogue of 64 Barkley Sound streams which provides information on: location, physical characteristics, forest cover, tenure status, biogeoclimatic variants and relative abundance of salmonid species. This catalogue was designed to provide a single source of the information considered essential to initial practical study designs for future fish/forestry research.

Codes: database

Brown, T. G., I. V. Williams, and R. T. E. Pulfer. 1987. Watershed database: Clayoquot Sound, Vancouver Island. Report ISSN 0706-6465. database.

Catalogue of 34 Clayoquot Sound streams which provides information on: location, physical characteristics, forest cover, tenure status, biogeoclimatic variants and relative abundance of salmonid species. This catalogue was designed to provide a single source of the information considered essential to initial practical study designs for future fish/forestry research.

Codes: database

Brusven, M. A., W. R. Meehan, and J. F. Ward. 1986. Summer use of simulated undercut banks by juvenile chinook salmon in an artificial Idaho channel. North American Journal of Fisheries Management 6: 32-37.

The effects of introducing simulated undercut stream banks on the distribution of juvenile chinook salmon (Oncorhynchus tshawytscha) were studied in a naturally vegetated, flow-regulated channel in Idaho in 1980 and 1981. In all tests, mean fish weight was greater in covered than in open sections. Preference for the covered versus uncovered experimental sections was highly significant during July and August tests. For all tests combined, 82% of the fish by numbers and 85% by biomass were collected in covered sections. The results suggest that undercut banks as simulated by artificial shelters, are an important summer habitat component for juvenile chinook salmon that should be carefully evaluated by the manager.

Codes: experi reach quant instream

Bryant, M. D. 1988. Gravel pit ponds as habitat enhancement for juvenile coho salmon. General Technical Report PNW-GTR-212. (USDA, Forest Service, Pacific Northwest Research Station, Portland, OR) 10p.

Gravel pits built during road construction in the early 1970's near Yakutat, Alaska, filled with water and were connected to nearby rivers to allow juvenile salmonids to enter. Seasonal changes in population size, length and weight, and length frequencies of the coho salmon (Oncorhynchus risutch) population were evaluated over a 2-year period. Numbers of coho salmon fluctuated, but two of the ponds supported high populations, 2,000 fish throughout the study. These ponds appeared to support coho salmon throughout the winter.

Codes: offchann quant

Bryant, M. D., P. E. Porter, and S. J. Paustian. 1991. Evaluation of a stream channel-type system for southeast Alaska. Report FSGTR-PNW-267.

Nine channel types within a hierarchical channel-type classification system were surveyed to determine relations between salmonid densities and species distribution, and channel type. Two other habitat classification systems and the amount of large woody debris also were compared to species distribution and salmonid densities, and to stream channel types. Although trends appeared in salmonid densities and channel types, population estimates were too variable to show a relation between density and channel types. Depth-velocity criteria that separated habitat into shallow-slow, deep-slow, shallow-fast, and deep-fast were poorly related to fish populations and channel types. Within Bisson classification system, coho salmon (Oncorhynchus kisutch) parr were positively correlated to off-channel habitat types. Large wood was more abundant in despositional channel types, and coho salmon densities were positively related to debris accumulations of 10 or more pieces and to rootwads.

Codes: multi reach quant lwd offchann instream warning

Bryant, M. D., D. N. Swanston, R. C. Wissmar, and B. E. Wright. 1998. Coho Salmon Populations in the Karst Landscape of North Prince of Wales Island, Southeast Alaska. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 127: 425-433.

Karst topography is a unique and distinct landscape and its geology may have important implications for salmon productivity in streams. The relationship between salmonid communities and water chemistry and the influence of habitat was examined in a set of streams on north Prince of Wales Island, southeast Alaska. Streams in karst landscapes showed higher alkalinities (1,500-2,300 mu eq/L) than streams not influenced by karst landscapes (750-770 mu eq/L). A significant, positive relationship was observed between alkalinity and density of coho salmon parr Oncorhynchus kisutch. Backwater pools supported higher densities of coho salmon than did other habitat units. Both coho salmon fry and parr tended to be larger in most karst-influenced streams than in nonkarst streams. Although past timber harvest practices in the riparian areas of several of the streams appeared to influence stream habitat and water temperature, streams flowing through karst landscapes had a distinct water chemistry. Furthermore, these streams appeared to support more fish than nonkarst streams.

Codes: multi habitat quant offchann lulc watqual

Bryant, M. D., B. E. Wright, and B. J. Davies. 1992. Application of a hierarchical habitat unit classification system: Stream habitat and salmonid distribution in Ward Creek, Southeast Alaska. Report FSRN-PNW-508.

A hierarchical classification system separating stream habitat into habitat units defined by stream morphology and hydrology was used in a pre-enhancement stream survey. The system separates habitat units into macrounits, mesounits, and microunits and includes a separate evaluation of instream cover that also uses the hierarchical scheme. The paper presents an application of the system to a pre-enhancement survey of habitat and salmonid populations. Application of the method accompanied by snorkel counts of fish allowed us to determine habitat area, salmonid densities within habitat units, and an estimate of the total salmonid population by species. The method is useful to rapidly describe and stratify stream habitat to determine salmonid distribution and abundance during stream surveys.

Codes: reach habitat quant instream

Bult, T., S. C. Riley, R. L. Haedrich, R. J. Gibson, and J. Heggenes. 1999. Density-dependent habitat selection by juvenile Atlantic salmon (Salmo salar) in experimental riverine habitats. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 56: 1298-1306.

Habitat use was investigated of Atlantic salmon (Salmo salar) parr in experimental riverine enclosures made up of pool, riffle, and run habitats over a range of densities (0.1-1.25 fish times m super(-2)) to test the implicit assumption in habitat modelling that habitat selection does not change with population density. Results indicated that habitat use changed with population density, with relatively more parr in pools and fewer in runs at higher population densities. Temperature influenced parr distribution, with relatively more parr in runs and fewer in riffles and pools at higher temperatures. Parr distribution was primarily affected by hydromorphological differences among pool, riffle, and run habitats. Effects of population density and temperature on use of pool, riffle, and run habitats were often as large as effects of hydromorphological differences among pool, riffle and run habitats on fish distributions over the range of temperatures and densities observed. Results varied considerably, despite controlled experimental conditions. It was concluded that habitat selection by juvenile Atlantic salmon parr may be density dependent and potentially quite variable.

Codes: enclos habitat quant popdyn wtemp

Bult, T. P., R. L. Haedrich, and D. C. Schneider. 1998. New technique describing spatial scaling and habitat selection in riverine habitats. Regulated Rivers: Research & Management [Regul. Rivers: Res. Manage.] 14: 107-118.

We propose a quantitative multi-scale technique based on frequency analysis and randomisation to study habitat selection by fish in riverine habitats. The technique can be used over any range of spatial scales in an environment with irregular boundaries. We illustrate the approach using simulated distributions and field data on juvenile Atlantic salmon (Salmo salar) distributions, obtained by snorkelling in North Harbour River, Newfoundland, Canada. We suggest that current habitat models may be improved by a more explicit use of space and time scales. Multi-scale approaches to study fish-habitat relationships and multi-scale habitat models may be better at capturing how fish are associated with their environment than single-scale approaches and models. Habitat selection studies should focus on identifying scales most appropriate to management questions. From this, management of fish populations and fish habitats may be improved.

Codes: reach habitat modeling

Burgess, S. A. 1985. Some effects of stream habitat improvement on the aquatic and riparian community of a small mountain stream. Edited by J. A. Gore. 223-246 p.

The purpose of this study was to determine the effectiveness of a relatively simple habitat improvement program in increasing trout (Salvelinus fontinalis) biomass in an experimental section of a small mountain stream. The intention was to use relatively simple techniques with low cost and labor requirements.

Codes: experi reach quant instream

Burgess, S. A., and J. R. Bider. 1980. Effects of Stream Habitat Improvements on Invertebrates, Trout Populations, and Mink Activity. Journal of Wildlife Management 44: 871-880.

A section of spring-fed mountain stream near Lac Carre, Quebec, was altered to provide improved habitat for brook trout. A similar 100 meter section of stream was left unimproved as a control. Changes included adding small dams of rocks and logs, large boulders, and cover. After 2 years the trout population and biomass in the improved stream increased by 208% and 179%, respectively; crayfish, by 220%. In the improved section, water temperatures were the same as in the control; insect populations were higher. Mink were 52.5% more active near the improved stream, but preyed mostly on crayfish and small mammals. Analysis of mink scats showed that trout were not an important prey. (Cassar-FRC).

Codes: experi reach quant instream

Burns, J. W. 1972. Some effects of logging and associated road construction on northern California streams. Transactions of the American Fisheries Society 101: 1-17.

The effects of logging and associated road construction on four California trout and salmon streams were investigated from 1966 through 1969. This study included measurements of streambed sedimentation, water quality, fish food abundance, and stream nursery capacity. Logging was found to be compatible with anadromous fish production when adequate attention was given to stream protection and channel clearance. The carrying capacities for juvenile salmonids of some stream sections were increased when high temperatures, low dissolved oxygen concentrations, and adverse sedimentation did not accompany the logging. Extensive use of bulldozers on steep slopes for road building and in stream channels during debris removal caused excessive streambed sedimentation in narrow streams. Sustained logging prolonged adverse conditions in one stream and delayed stream recovery. Other aspects of logging on anadromous fish production on the Pacific Coast are discussed.

Codes: multi experi reach quant lulc instream substrate wtemp watqual

Cade, B. S., and J. W. Terrell. 1997. Comment: Cautions on forcing regression equations through the origin. North American Journal of Fisheries Management 17: 225-227.

Bourgeois et al. (1996) evaluated relationships between weighted usable habitat area (WUA) and density of juvenile Atlantic salmon Salmo salar in New Brunswick stream. They were testing one of the most criticized features of the instream flow incremental methodology: the assumption that fish standing stock is positively correlated with WUA. They estimated fish densities by electrofishing, and they calculated WUAs for day-of-sampling and averaged streamflows. Then they used regression analysis to assess how the relation y = beta sub(0) + beta sub(1)X sub(1) + epsilon between fish density (y) and WUA (X sub(1); epsilon is an error term) was affected by season (summer, autumn), year (1990-1992), and spatial scale (habitat, reach, basin). They also examined the effect of forcing each regression through the origin (y = beta sub(1)X sub(1) + epsilon) on the grounds that "no habitat equals no fish." They reported that "in most cases, forcing the intercept to 0 improved the r super(2) from a low nonsignificant relation to a highly significant relation" and documented the changes in their Table 5. One must ask how a linear regression model with only one parameter (slope) can fit data better (have a higher r super(2)) than a two-parameter model (slope and intercept). The answer is that it cannot. The real cause of he apparent improvement was a change in the underlying null model.

Codes: ifim stats warning hem

Campbell, E. A. 1999. Influence of Streamflow and Predators on Habitat Choice by Trout

I examined the effect of flow and presence of large brown trout (potential predators) on habitat choice by juvenile rainbow trout and brook charr. Experiments were conducted in a large (8.1 m x 1.5 m) stream enclosure with a pool-riffle-pool configuration. Large brown trout, when present, were confined to the upstream pool. Juvenile trout and charr tended to leave the riffle and occupy the pools when flow was low. They also were less likely to be found in the upstream pool when large brown trout were present; juvenile fish remaining in the upstream pool avoided the deep area with cover favored by the large brown trout especially at sunset and at night at high flow. Low flow apparently caused juvenile trout and charr to inhabit pools with large brown trout that they would otherwise avoid. Observations of marked individuals indicated that juvenile fish increased their preference for shallower water of intermediate velocity when flow changed from low to high, even after adjusting for different depth and velocity availabilities. This suggests that depth and velocity preferences were flow dependent. Furthermore, velocity choice of aggressive fish increased more than for non- aggressive individuals, and velocity choice of rainbow trout increased more than for brook charr. Feeding rates of juvenile rainbow trout and brook charr declined both when flow was low and when large brown trout were present, although aggressive fish had higher overall feeding rates than non-aggressive individuals. Feeding rates were likely affected by changes in food availability related to both flow level and changes in local fish density, as well as the aggressiveness of individual fish. This result indfcates that microhabitats having water of the same velocity may not always be of the same value to drift-feeding juvenile salmonids. Overall, this study has shown that flow and predator effects on juvenile salmonid habitat choice are extremely complex. Both habitat use and feeding rate were strongly affected by flow, predator presence, diel period, and the aggressiveness level of individual fish. Interactions among these variables were common. Models used to recommend instream flows for regulated streams may not adequately evaluate stream fish habitat.

Codes: enclos reach habitat quant trophic sppinter warning

Capra, H. 1995. Improvement of habitat models for brown trout: sampling scales; utilization of habitat time series. Report; Dissertation Dissertation, Lyon-1 Univ., France Univ. Claude Bernard.

Our goals, to increase predictive power of fish / habitat relationships simulations were: (1) to develop a new biological model (in contrast with suitability curves); (2) to analyse relationships between habitat time series and fish population dynamics. Fish Habitat relationships modelling at a local scale individual to perform a vital activity. This new sampling scale, called minihabitat (Ambiance in french), is larger than the focal point (snout fish) but smaller than the morphological unit in habitat hierarchy. 1- The minihabitat sampling procedure enables to get biological data representative of population structure, and physical data representative of available habitat in a stream segment. 2- The multiple regression on variabiliy of the three physical parameters (Depth, velocity and substrate) has the best predictive power and is the most transferable model to predict minihabitat trout density. Integrating habitat temporal dynamics The main aim of this study was to found habitat bottlenecks for different trout life stages. 1- A new tool was developed to study habitat (or discharge) time series. In fact, it enables to identify Continuous Under-threshold Durations (CUT curves) (DCHL in french) during which available habitat is less than the threshold value. 2- Two life stages were sensible to habitat fluctuations. Habitat conditions during reproduction and post-emerging periods both influence the strength of the young of the year after and of the adults three years after. Habitat conditions during long low flow periods influence the strength of the adult of the same year. This study points out the need of a definition of a instream regime, more than an instream flow.

Codes: modeling microhab instream temporal foreign

Capra, H., P. Breil, and Y. Souchon. 1995. A new tool to interpret magnitude and duration of fish habitat variations. Regulated Rivers: Research & Management 10: 281-289.

The main result of habitat simulation procedures is a static relationship between an index of potential habitat, e.g. weighted usable area (WUA), versus discharge in a study reach representative of a stream. A new methodology was developed to analyse the timing and magnitude of physical habitat variations. Three options are presented: (i) the habitat time series; (ii) the habitat duration curves; and (iii) the continuous under threshold habitat duration curves. The last option is a new procedure to interpret habitat chronicles. It determines continuous durations during which the total WUA in a study reach was lower than a given threshold. The assumption according to which some durations/threshold values could represent limiting events for fish population dynamics is illustrated with surveys of two wild brown trout populations. The relationship between spawning habitat conditions and the relative density of 0+ the year after was studied. A continuous duration of more than 20 days with spawning habitat conditions lower than 80% of the optimum conditions seemed to limit the number of 0+ trout. This procedure is presented as a tool to interpret natural discharge time series for management.

Codes: microhab modeling instream ifim hydro hem

Cederholm, C. J., R. E. Bilby, P. A. Bisson, T. W. Bumstead, B. R. Fransen, W. J. Scarlett, and J. W. Ward. 1997. Response of juvenile coho salmon and steelhead to placement of large woody debris in a coastal Washington stream. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 17: 947-963.

Many fish habitats have been altered in Pacific Northwest streams and rivers over the past century by a variety of land use practices, including forestry, urbanization, agriculture, and channelization. There are research and management needs for evaluation of the effectiveness of rehabilitation projects intended to enhance stream fish habitat recovery. The response of populations of juvenile coho salmon Oncorhynchus kisutch and steelhead O. mykiss to addition of large woody debris (LWD) was tested in North Fork Porter Creek (NFPC), a small coastal tributary of the Chehalis River, Washington. The NFPC was divided into three 500-m study sections; two sections were altered with two approaches (engineered and logger's choice) to adding LWD, and the third was kept as a reference site. Immediately after LWD addition, the abundance of LWD pieces was 7.9 times greater than the pretreatment level in the engineered site and 2.7 times greater in the logger's choice site; abundance was unchanged in the reference site. Subsequent winter storms brought additional LWD into all three study sites. In the years that followed, the amount of pool surface area increased significantly in both the engineered and logger's choice sites, while it decreased slightly in the reference site. After LWD addition, winter populations of juvenile coho salmon increased significantly in the engineered and logger's choice sites, while they remained the same in the reference site. There were no significant differences in the coho salmon populations during spring and autumn within the reference, engineered, or logger's choice sites. The coho salmon smolt yield from the engineered and logger's choice sites also increased significantly after LWD addition, while it decreased slightly in the reference site. After LWD addition, the reference site and the engineered site both exhibited increases in age-0 steelhead populations; however, the population in the logger's choice site did not change. There was no difference in age-1 steelhead abundance among sites, or before and after enhancement during any season. Winter populations of juvenile coho salmon and age-0 steelhead were related inversely to maximum and mean winter discharge.

Codes: experi quant lwd hydro

Cederholm, C. J., L. M. Reid, and E. O. Salo. 1981. Cumulative Effects of Logging Road Sediment on Salmonid Populations in the Clearwater River, Jefferson County, Washington. Pages 38-74 in Proceedings of a conference "Salmon spawning gravel: a renewable resource in the Pacific Northwest?" Report 39, Washington Water Resource Center, Washington State University, Pullman, WA.

In 1971 a series of massive landslides on the west coast of the Olympic Peninsula, which included both logging and road sidecast failures, prompted research on the sedimentation of salmonid spawning habitats. The sedimentation from logging road activities has caused long-term concern for fisheries resources of the Clearwater River. This study included analyses of field situations supplemented by controlled experiments. Significant amounts (15-25 percent) of fine sediments (less than 0.85 mm diameter material) are accumulating in spawning gravels of some heavily roaded tributary basins. This accumulation is highest where the road area exceeds 2.5 percent of the basin area. Tributaries of relatively steep gradient are less likely to accumulate high levels of fines. The survival of salmonid eggs to emergence is inversely correlated with percent fines when the percentage of fines exceeds the natural level of 10 percent. The presence of 2.5 km/km-squared of gravel-surfaced roads undergoing an average distribution of road uses is found to be responsible for producing sediment at 2.6 to 4.3 times the natural rate in a drainage basin. Sixty percent of the road-related sediment production is caused by landslides, while 18-26 percent is caused by erosion on road surfaces. However, if fine sediment alone is considered, the production from road surfaces and landslides is nearly equal. (Garrison-Omniplan).

Codes: multi reach qual spawn substrate

Chapman, D. W. 1995. Efficacy of structural manipulations of instream habitat in the Columbia River basin. Rivers 5: 279-293.

Instream habitat structures designed to enhance salmon populations have been placed in many tributaries in the Columbia River basin. Examination of test data reveals little reliable evidence of benefits. Suitable protocols for study require many years and suitably paired test and reference areas; a commitment of resources not evident to date. Emphasis on instream structures reduces emphasis on problems that contribute to loss of instream habitat quality. I suggest that managers shift attention to watershed husbandry instead of relying on instream palliatives.

Codes: review multi experi instream lulc warning

Chapman, D. W., and E. Knudsen. 1980. Channelization and Livestock Impacts on Salmonid Habitat and Biomass in Western Washington. TAFS 109: 357-363.

The authors examined salmonid habitat and biomasses in 50-70-m pairs of altered and control sections of small (discharges less than 0.3 m super (3) second super (-1)) streams around Puget Sound in western Washington in 1978-1979. Altered sections had been channelized or used by livestock. Channelization significantly reduced overhead cover, sinuosity, wetted area, and woody bank cover while increasing bank grasses. Total habitat area declined in altered areas. These impacts most damaged the quality of habitat for cutthroat trout (Salmo clarki) over 70 mm in length. Biomass of coho salmon (Oncorhynchus kisutch) did not decline significantly in altered sections except in areas severely damaged.

Codes: multi experi reach quant graz ripar

Chisholm, I. M., and W. A. Hubert. 1986. Influence of stream gradient on standing stock of brook trout in the Snowy Range, Wyoming. Northwest Science 60: 137-139.

Gradient and other instream habitat variables were assessed for their influence on brook trout (Salvelinus fontinalis) abundance in small streams where brook trout were the only fish species present. Brook trout occurred throughout the gradient-range studied (0.4-9.2 percent), but increased gradient had a negative influence on abundance. Gradient, width to depth ratio, mean depth, and mean width accounted for 68.8% of the variation in brook trout abundance among the 24 study reaches.

Codes: multi reach quant instream

Clark, M. E., and K. A. Rose. 1997. Factors affecting competitive dominance of rainbow trout over brook trout in southern Appalachian streams: Implications of an individual-based model. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 126: 1-20.

We used an individual-based model to examine possible explanations for the dominance of rainbow trout Oncorhynchus mykiss over brook trout Salvelinus fontinalis in southern Appalachian streams. Model simulations were used to quantify the effects on interspecific competition of (1) competitive advantage for feeding sites by rainbow trout, (2) latitudinal differences in stream temperatures, flows, and daylight, (3) year-class failures, (4) lower fecundity of brook trout, and (5) reductions in spawning habitat. The model tracks the daily spawning, growth, and survival of individuals of both species throughout their lifetime in a series of connected stream habitat units (pools, runs, or riffles). Average densities of each species based on 100-year simulations were compared for several levels of each of the five factors and for sympatric and allopatric conditions. Based on model results and empirical information, we conclude that more frequent year-class failures and the lower fecundity of brook trout are both possible and likely explanations for rainbow trout dominance, that warmer temperatures due to latitude and limited spawning habitat are possible but unlikely explanations, and that competitive advantage for feeding sites by rainbow trout is an unlikely explanation. Additional field work should focus on comparative studies of the reproductive success and the early life stage mortalities of brook and rainbow trout among Appalachian streams with varying rainbow trout dominance.

Codes: habitat modeling popdyn sppinter instream wtemp temporal

Clark, M. E., K. A. Rose, D. A. Levine, and W. W. Hargrove. 2001. Predicting climate change effects on Appalachian trout: Combining GIS and individual-based modeling. Ecological Applications 11: 161-178.

We coupled an individual-based model of brook trout (Salvelinus fontinalis) and rainbow trout (Oncorhynchus mykiss) with a geographic information system (GIS) database to predict climate change effects on southern Appalachian stream populations. The model tracked individuals of both species through the daily processes of spawning, growth, feeding, mortality, and movement for 30 years in a stream reach consisting of connected pools, runs, and riffles. The southern Appalachian Plateau was divided into 101 watershed elevation band zones. Model simulations were performed for a representative stream reach of each stream order in each zone. Trout abundance was estimated by multiplying predicted trout densities (measured in number of trout per meter) by the total length of streams of each order in each watershed elevation zone. Three climate change scenarios were analyzed: temperature only (1.5-2.5[degree]C warmer stream temperatures); temperature and flow (warmer stream temperatures and lower baseline flows with threefold higher peak flows); and temperature, flow, and mortality episodes (warmer stream temperatures, changed flows, and flow-related scouring of redds). Increased temperature alone resulted in increased abundances of brook and rainbow trout. The temperature-and-flow scenario resulted in a complex mosaic of positive and negative changes in abundances in zones, but little change in total abundance. Addition of episodic mortality in the form of floods that scour redds and kill eggs and fry caused a net loss of rainbow trout. Predicted changes in habitat (based on simulation results and temperature alone) were, at best, weakly correlated with predicted changes in abundance. The coupling of individual-based models to GIS databases, in order to scale up environmental effects on individuals to regional population responses, offers a promising approach for regional assessments.

Codes: multi reach modeling popdyn sppinter instream wtemp temporal lulc

Clarke, K. D., and D. A. Scruton. 1999. Brook trout production dynamics in the streams of a low fertility Newfoundland watershed. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 128: 1222-1229.

Production of brook trout Salvelinus fontinalis ranged from 99 to 651 g times 100 m super (-2) times year super(-1) among headwater streams of the Copper Lake watershed in insular Newfoundland. Ratios of annual production to mean annual biomass (P/B) ranged from 0.9 to 1.5 among the same streams. Empirical models developed from stream salmonid populations in the United States successfully predicted modal production based on water alkalinity and P/B ratios based on age-class structure of the populations. Differences in production among streams were consistent with previous work in low-fertility headwater systems, which suggests habitat attributes of the stream define salmonid production within the range dictated by the water fertility. The most important of these attributes in this study was food abundance. Substrate composition and habitat complexity may have played secondary roles in determining production in the most productive stream.

Codes: multi reach quant instream trophic

Clarkson, R. W., and J. R. Wilson. 1995. Trout biomass and stream habitat relationships in the White Mountains area, east-central Arizona. Transactions of the American Fisheries Society 124: 599-612.

We surveyed stream habitats and fish populations at 243 stations among 21 high-elevation trout streams in the Apache-Sitgreaves National Forest and White Mountain Apache Reservation in the White Mountains area, east-central Arizona, from 1986 to 1990. The White Mountains area makes up most of the historic habitat for Apache trout Oncorhynchus apache, listed by the U.S. federal government as a threatened species. A generalized linear model relating trout biomass and stream, riparian, and geomorphic habitat variables was developed (R super(2) = 0.68). Among the significant variables in the systematic components of the model, bank damage by ungulates was the only variable solely influenced by land management practices. We attribute the bulk of the bank damage to domestic cattle grazing and conclude that better cattle management is necessary for improvement of trout habitats. Another significant variable, channel width, was partly dictated by geomorphology but was also correlated with bank damage by ungulates. Three significant variables in the model were completely geomorphic (station elevation, channel type, riparian area width) and thus not useful for management purposes. The model coefficient of determination was relatively low in comparison with some other trout-habitat models developed in the western USA. This result may indicate that trouts in our study area are limited less by physical habitat than by climatic events or predation and competition influences.

Codes: reach multi graz ripar quant

Conder, A. L., and T. C. Annear. 1987. Test of Weighted Usable Area Estimates Derived from a PHABSIM Model for Instream Flow Studies on Trout Streams. North American Journal of Fisheries Management 7: 339-350.

An assessment was made of the biological validity of weighted usable area (WUA) from the physical habitat simulation (PHABSIM) model based on standing crops of trout (Salvelinus and Salmo spp.) measured in Wyoming streams and standing crops predicted by the habitat quality index (HQI). Tests were made in trout streams for (1) validity of the HQI, (2) relationships between WUA and measured standing crops in different streams, and (3) relationships between WUA and the HQI within streams. Significant correlation ($r=0.934$; $P<0.05$) was found between HQI scores and trout standing crop during the low-flow period. No significant correlation was found for WUA and the measured standing crop among different streams; correlation coefficients for all tests were either near zero or moderately negative. Significant positive correlation ($P<0.05$) did exist for 7 of the 60 within-stream analyses of WUA vs. HQI; 19 other positive correlations were strong ($r>0.90$), but statistical significance was limited by the number of data points at each site. Although positive correlations were expected for all 60 cases, 18 tests showed a negative correlation, 3 of which were significant. Analyses indicated that trout species, stream size, and stream gradient influence the validity of the within-stream relationship between WUA and the trout standing crop predicted by the HQI. Among test streams with steeper gradients and where velocity exerted the greatest influence on the HQI score, apositive correlation was observed in all cases, regardless of stream size or dominant species. When an attribute other than velocity has the greatest influence on trout density with change in discharge, WUA estimates may be invalid. This observation indicates that a relationship between WUA and trout standing crop may exist, but the nature of the relationship is likely to be unique for each stream. (Author 's abstract).

Codes: multi reach quant instream ifim warning hem

Connolly, P. J. 1997. Influence of stream characteristics and age-class interactions on populations of coastal cutthroat trout. Edited by J. D. Hall, P. A. Bisson and R. E. Gresswell. American Fisheries Society, Oregon Chapter, Corvallis, Oregon (USA)

Resident cutthroat trout are often the only salmonid species, and sometimes the only fish species, occupying first- and second-order streams in the central Oregon Coast Range. As cutthroat trout grow, the habitat they utilize changes. Age-0 cutthroat trout are often associated with the lateral margins of a stream, whereas age-1 and older cutthroat trout are largely associated with pools. Bisson et al. observed that cutthroat trout of all ages generally preferred cover provided by woody debris in both pool and riffle habitats. In this paper, I show that complex age-class and habitat interactions may regulate recruitment success of cutthroat trout. I argue that this possibility should be considered in evaluating the health of populations and the effects of stream restoration projects.

Codes: multi reach qual popdyn lwd instream warning

Connolly, P. J., and J. D. Hall. 1999. Biomass of coastal cutthroat trout in unlogged and previously clear-cut basins in the central Coast Range of Oregon. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 128: 890-899.

Populations of coastal cutthroat trout Oncorhynchus clarki clarki were sampled in 16 Oregon headwater streams during 1991-1993. These streams were above upstream migration barriers and distributed among basins that had been logged 20-30 and 40-60 years ago and basins that had not been logged but had burned 125-150 years ago. The objective of our study was to characterize the populations and habitats of age-1 or older cutthroat trout within these three forest management types. Streams within unlogged basins had relatively low levels and a small range of trout biomass (g/m super(2)). Streams in basins logged 40-60 years ago supported low levels but an intermediate range of trout biomass. Streams in basins logged 20-30 years ago supported the widest range of biomass, including the lowest and highest biomasses among all streams sampled. The variable that best explained the variation of trout biomass among all 16 streams was the amount of large woody debris (LWD). All streams were heavily shaded during at least part of the year by mostly closed tree canopies. Deciduous trees were more prominent in canopies over streams in logged basins, while conifers were more prominent in the stream canopies of unlogged basins. Our results suggest that trout production in basins extensively clear-cut 20-60 years ago may generally decrease or remain low over the next 50 or more years because of decreasing loads of remnant LWD, persistent low recruitment potential for new LWD, and persistent heavy shading by conifers. These logged basins are not likely to show an increase in trout biomass over the next 50 years unless reset by favorable natural disturbances or by habitat restoration efforts.

Codes: multi habitat quant ripar lwd lulc

Contor, C. R., E. Hoverson, P. Kissner, and J. Volkman. 1996. Umatilla Basin natural production monitoring and evaluation. Annual progress report, 1994--1995. Report

This report summarizes the activities of the Umatilla Basin Natural Production Monitoring and Evaluation Project (UBNPME) from September 30, 1994 to September 29, 1995. This program was funded by Bonneville Power Administration and was managed under the Fisheries Program, Department of Natural Resources, Confederated Tribes of the Umatilla Indian Reservation. An estimated 36.7 km (22.6 miles) of stream habitat were inventoried on the Umatilla River, Moonshine, Mission, Cottonwood and Coonskin Creeks. A total of 384 of 3,652 (10.5%) habitat units were electrofished. The number of juvenile fish captured follows: 2,953 natural summer steelhead (including resident rainbow trout; Oncorhynchus mykiss), one hatchery steelhead, 341 natural chinook salmon (O. tshawytscha), 163 natural coho salmon (O. kisutch), five bull trout (Salvelinus confluentus), 185 mountain whitefish (Prosopium williamsoni), and six northern squawfish (Ptychoicheilus oregonensis). The expanded population estimate for the areas surveyed was 73,716 salmonids with a mean density of 0.38 fish /m(sup 2). Relative salmonid abundance, seasonal distribution and habitat utilization were monitored at index sites throughout the basin. During index site monitoring, the following species were collected in addition to those listed above: american shad (Alosa sapidissima), smallmouth bass (Micropterus dolomieu), carp (Cyprinus carpio) and chiselmouth (Acrocheilus alutaceus). Thirty-nine sites were electrofished during the spring and summer seasons, while 36 sites were sampled in the fall season. A study of the migration movements and homing requirements of adult salmonids in the Umatilla River was conducted during the 1994-95 return years. Radio telemetry was used to evaluate the movements of adult salmonids past diversion dams in the lower Umatilla River and to determine migrational movements of salmonids following upstream transport.

Codes: multi quant migrat instream database

Contor, C. R., and W. S. Platts. 1991. Assessment of COWFISH for predicting trout populations in grazed watersheds of the intermountain west. Report FSGTR/INT-278. reach multi graz quant modeling warning.

COWFISH (Lloyd 1986) is a model designed to estimate livestock impacts on stream-riparian features and to estimate impacts on fish abundance and fisheries economic values. The EPA (1987) reports that COWFISH was designed for conditions in Montana, but that it is usable, with alterations, throughout the Western United States. A study applied the COWFISH model to a variety of streams in the intermountain West to determine its capability to estimate fish populations in grazed watersheds. Testing on 14 streams in Idaho, Nevada, and Utah revealed that the model had little value for predicting numbers of trout in watersheds grazed by livestock. The model holds promise for estimating the health of stream channels and riparian complexes.

Codes: reach multi graz quant modeling warning

Coutant, C. C. 1996. Comment: effects of instream brush on juvenile coho salmon. Transactions of the American Fisheries Society 125: 150-151.

Spalding et al. (1995) concluded that four configurations of brush (Christmas trees) suspended in an artificial stream channel at differing branch densities had no discernible effects on rearing of first-year coho salmon Oncorhynchus kisutch. The focus of their experiments was on brush as cover-as an attractant, as protection from predators, as a shield from aggression between individuals, and as an aid to foraging efficiency. Although the experiment seems well designed for its objectives, it did not capture some of the potentially important benefits of brushy debris for young salmon. Thus, it could mislead those who attempt to rehabilitate rearing habitats for coho salmon and other salmon species. An alternative or additional hypothesis for their study could have focused on the role of submerged brush as a substrate for production of invertebrate food.

Codes: experi quant habitat lwd warning

Crisp, D. T. 1993. Population densities of juvenile trout (Salmo trutta) in five upland streams and their effects upon growth, survival and dispersal. Journal of Applied Ecology 30: 759-771.

Survival, growth and downstream dispersal of trout (especially 0 group) and the relationships of these variables to initial stocking density were studied in north Pennine streams. Two methods were used.First, electrofishing censuses were made in a marked reach of each of four streams over a period of about 20 years. Second, downstream moving trout were trapped in two streams over a 10-year period. Each stream upstream of the trap was experimentally stocked with "swim-up" trout fry, using a different population density each year. Before 1970 the four census reaches showed very large year-upon-year variations in August trout parr densities, with local failures of recruitment in some years. Survival (including the effects of losses by dispersal) from swim-up to early August, for starting population densities of 0-10 fry/m super(2), was about 10% regardless of initial density. Estimates of survival from August to early October were 30-50% for the census reaches and 55-65% for the areas upstream of the traps. However, for August 0 group densities of 0-0.9/m super(2), estimated instantaneous loss rate from August of the first year of life up to age 40-65 months showed a positive curvilinear relationship to population density in the first year of life. Loss rate was, therefore, density-dependent during this period. At starting densities around 4-5 fish/m super(2) dispersal was negligible. As initial density rose above 4-5 fish/m super(2) and towards 10 fish/m super(2) the percentage of loss attributable to dispersal rose towards 30%. As initial densities decreased from 4 to

1.4 fish/m super(2), the percentage rose to around 20%. Below a starting density of 1.4 fish/m super(2) the percentage decreased.

Codes: multi reach quant popdyn migrat temporal

Culp, J. M. 1986. Experimental evidence that stream macroinvertebrate community structure is unaffected by different densities of coho salmon fry. Journal of the North American Benthological Society 5: 140-149.

Manipulative field enclosure/exclosure experiments were carried out in Carnation Creek, British Columbia to determine if patch-restricted coho fry (Onchorhynchus kisutch) affected the distribution and abundance of macroinvertebrates in the drift or benthos. Density, biomass, and size distribution of macroinvertebrates in the drift were not significantly affected by fish density treatment. Additionally, with the exception of large swimming larvae of Ameletus sp. and Baetis tricaudatus, macroinvertebrate density, size distribution, and biomass in the benthos were also not significantly affected by fish density treatments. Thus, despite fish densities being increased from two to four times above ambient patch levels, patch-restricted coho fry had little measurable effect on macroinvertebrate distribution and abundance in Carnation Creek during the low discharge period of August to September.

Codes: experi enclos habitat quant trophic

Culp, J. M., G. J. Scrimgeour, and G. D. Townsend. 1996. Simulated fine woody debris accumulations in a stream increase rainbow trout fry abundance. Transactions of the American Fisheries Society 125: 472-479.

Habitat for young-of-the-year rainbow trout Oncorhynchus mykiss was enhanced in a fourth-order stream during August-October 1991 by the addition of wooden structures that simulated accumulations of fine woody debris (FWD). The experiment represented a two-factorial design with the presence or absence of FWD bundles and time since debris introduction as factors. Immediately after FWD placement, fry density, individual biomass, fry condition factor, and total fry biomass were similar in treated and untreated sites. As the experiment progressed, density and total fry biomass significantly increased at treated but not at untreated sites. Individual biomass and condition factor did not differ between treated and untreated areas, and they were affected only by time since FWD placement. Because individuals at treated and untreated sites were the same size, added FWD did not affect an individual's net rate of energy gain. Rather, we hypothesize that the FWD provided structurally complex habitat that acted as a refuge from predators and as sites from which foraging forays were staged. Adding FWD to a stream can increase carrying capacity for trout fry, and adult population density may increase as a result.

Codes: experi habitat quant lwd

Cunjak, R. A. 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. CAJFS 53: 267-282.

This paper reviews the habitat characteristics and the behaviour of selected stream fishes during winter in temperate-boreal ecosystems. Emphasis is placed on the salmonid fishes upon which most winter research has been directed. As space is the primary factor regulating stream fish populations in winter, aspects of winter habitat are considered at various spatial scales from microhabitat to stream reach to river basin. Choice of winter habitat is governed by the need to minimize energy expenditure, with the main criterion being protection from adverse physicochemical conditions. The distance moved to wintering habitats, and the continued activity by many fishes during the winter, need to be considered when making management decisions regarding fish habitat. How habitat is affected by land-use activity in stream catchments is discussed with reference to impacts from water withdrawal, varying discharge regimes, and erosion or sedimentation. Even stream enhancement practices can deleteriously affect stream habitat if project managers are unaware of winter habitat requirements and stream conditions.

Maintenance of habitat complexity, at least at the scale of stream sub-basin, is recommended to ensure the diversity of winter habitats for fish communities.

Codes: review habitat migrat qual substrate instream lulc

Cunjak, R. A., T. D. Prowse, and D. L. Parrish. 1998. Atlantic salmon (Salmo salar) in winter: 'The season of parr discontent?'. Canadian Journal of Fisheries and Aquatic Sciences 55: 161-180.

Effects of the winter regime on northern streams and rivers is extremely variable and characterized by dramatic alterations in physical habitat to which Atlantic salmon (Salmo salar) must acclimate and adapt to survive. This paper synthesizes recent advances in the biological and hydrologic/geomorphic disciplines, with specific reference to Atlantic salmon overwintering in the freshwater portions of those running waters subject to freezing water temperatures. The specific requirements and adaptations for surviving winter at the three distinct life-stages in freshwater (egg, parr, kelt) are identified in relation to the characteristics of three biophysical phases: early winter, midwinter, and the break-up/warming phase. In a case study of Catamaran Brook (New Brunswick), a hydro-ecological analysis was used to explain interannual variability in juvenile abundance, especially for young-of-the-year salmon. A strong relation was found between winter discharge and interstage survival in 5 of 6 years. That is, juvenile salmon abundance in summer was highest following winters with high streamflow, presumably a function of habitat availability, especially beneath ice cover. The lowest measured egg-0+ survival (9.2%) was related to an atypical midwinter, dynamic ice break-up triggered by a rain-on-snow event that resulted in severe scouring of the stream-bed and redds. Interannual variability in Atlantic salmon parr abundance from 1990 to 1996 was largely explained by density-independent (environmental) constraints to winter survival. The complexity of stream processes during winter underscores the need for interdisciplinary research to quantify biological change.

Codes: reach quant popdyn hydro temporal noenv

Cunjak, R. A., and J. Therrien. 1998. Inter-stage survival of wild juvenile Atlantic salmon, Salmo salar L. Fisheries Management and Ecology [Fish. Manage. Ecol.] 5: 209-223.

A biological model was developed to calculate annual survival between life stages of juvenile Atlantic salmon, Salmo salar L., in Catamaran Brook, a small stream basin (52 km super(2)) in the Miramichi River catchment in New Brunswick, Canada. Seven years' data (1990-1996) were used in the model. Input variables included: daily fish counts and measurements of parr (3-4 age classes), smolts, and adult salmon at a fish-countingfence near the stream mouth; biennial quantification of all habitat types along the watercourse; fish density estimated by electric fishing at 30 sites; and estimates of young-of-the-year emigration via stream drift. Continuous recording of stream discharge provided data to assist in interpretation of survival estimates. Annual survival for juvenile salmon in their first 3 years of life in the stream averaged between 31% and 34%. The greatest annual variation (CV = 0.699) occurred at the egg to 0+ (summer) stage with a low of 9.2% survival recorded for a winter with an atypical midwinter flood event; parr and pre-smolt survival were similarly affected. Survival from egg deposition (after correction for losses caused by predation and retention/non-fertilization) to smolt emigration was between 0.16% and 0.52%, which is low relative to estimates from many other studies. Survival of smolts to returning 1-sea-winter adults (grilse) averaged 8.5%. Potential errors in the computation of the model are discussed, e.g. inaccurate counts of spawning adults during high autumn stream flow. A possible explanation for the low egg to smolt survival was the environmental conditions experienced during various winters. Mean egg survival was 1.3 times higher (39.3%) and egg to smolt survival increased to 1.03% when the two winters characterized by extremely low discharge or midwinter freshets were excluded from the calculation. Density-dependent factors related to a beaver dam, which limited spawning distribution, may also have contributed to poor survival and increased fry emigration in one year. Environmental factors, particularly winter conditions, in streams such as Catamaran Brook may act as bottlenecks to natural production of Atlantic salmon.

Codes: reach quant popdyn instream hydro temporal

Dahl, J. 1998. Effects of a benthivorous and a drift-feeding fish on a benthic stream assemblage. Oecologia 116: 426-432.

I assessed the impact of both drift-feeding (Salmo trutta, brown trout) and benthic-feeding (Cottus gobio, bullhead) fish on a benthic assemblage during a 1-month-long field experiment. I used enclosures containing cobble/gravel substrata with 6-mm mesh net that allowed invertebrates to drift freely in and out of enclosures. Four treatments, arranged in a factorial design, were tested: a predator-free control, bullheads only (2.67 bullheads/m super(2), two per enclosure), brown trout only (2.67 brown trout/m super(2), two per enclosure), and bullheads and brown trout together (2.67 fish/m super(2), one of each). Bullheads reduced the densities of seven invertebrate taxa (Gammarus pulex amphipods, Baetis rhodani mayfly nymphs, Leuctra spp. stonefly nymphs, Polycentropus spp. caddis larvae, Pacifastacus leniusculus signal crayfishes, Simuliidae, blackfly larvae, and Limnephilidae, caddis larvae) whereas brown trout only affected one taxon (B. rhodani). The weaker effect of brown trout on benthic prey was probably related to its heavy reliance on terrestrial prey. Dietary analyses showed that more than 80% of prey consumed by brown trout were terrestrial animals, whereas bullhead only consumed benthic prey. Neither bullhead nor brown trout affected the absolute number of immigrating or emigrating invertebrates in enclosures, but bullhead affected the per capita emigration rates of G. pulex. Direct predation by bullhead was more important than avoidance behavior (drift) in determining densities of six of the seven taxa; only G. pulex densities were equally affected by avoidance behaviour and direct predation. Direct predation by brown trout was also more important in determining densities of B. rhodani. The presence of bullhead raised periphyton biomass, presumably mediated via their consumption of grazers. Brown trout had no effect on periphyton biomass and these results indicate that the presence of alternative prey, in this case terrestrial animals, may have repercussions for fish-benthic macroinvertebrate-periphyton interactions and may potentially explain some of the variable impacts of fish on benthic macroinvertebrates that have been reported in the literature.

Codes: habitat enclos sppinter quant

Dauble, D. D., and D. R. Geist. 2000. Comparison of mainstem spawning habitats for two populations of fall chinook salmon in the Columbia River basin. Regulated Rivers Research & Management 16: 345-361.

Extensive hydroelectric development in the Columbia River system has eliminated most mainstem riverine habitat available for spawning by fall chinook salmon (Oncorhynchus tshawytscha). The two remaining populations, Hanford Reach, Columbia River and Hells Canyon Reach, Snake River, are separated geographically and their status is markedly different. Annual escapements to Hanford Reach have averaged approximately 80000 adults, while the Snake River run size has declined to < 1500 adults over the past 10 years. We compared their spawning habitat characteristics over a range of measurement scales, as a means to identify strategies for rebuilding the weak Snake River population. Physical habitat characteristics of redds were similar for both study areas. Redd locations were correlated with channel characteristics, such as braiding and sinuosity. Several differences between the two spawning areas were identified at the watershed scale: the Hells Canyon Reach had a much steeper longitudinal gradient, was largely confined by bedrock, and had a more variable flow regime. These features are controlling variables that operate at the reach-scale to limit the availability and size of substrate and other conditions that influence egg deposition and incubation survival. Geomorphological characteristics of the two study sites are sufficiently different to indicate that the production potential of the Hells Canyon Reach population is markedly lower than that of the Hanford Reach population.

Codes: basin spawn qual instream substrate temporal

Davies, P. E., and M. Nelson. 1994. Relationships between riparian buffer widths and the effects of logging on stream habitat, invertebrate community composition and fish abundance. Aust. J. Mar. Freshwat. Res. 45: 1289-1305.

Impacts from the logging of Eucalyptus forest on stream habitat, macroinvertebrate abundance and diversity, and fish abundance were surveyed in Tasmania, Australia. Forty-five pairs of sites from 34 streams of greater than or equal to 2.5 km super(2) catchment area were each sampled once during summer in the period 1990-92. Each site pair consisted of an 'impacted' site downstream of a logging treatment and an upstream or closely matched 'paired control' site. Site pair treatments encompassed two logging methods (cable and conventional) with a range of riparian buffer strip widths (0-50 m) and included unlogged controls. Differences between site pair variables were used as test statistics for the detection of logging impacts. Logging significantly increased riffle sediment, length of open stream, periphytic algal cover, water temperature and snag volume. Logging also significantly decreased riffle macroinvertebrate abundance, particularly of stoneflies and leptophlebiid mayflies, and brown trout abundance. All effects of logging were dependent on buffer strip width and were not significantly affected by coupe slope, soil erodibility or time (over one to five years) since logging. All impacts of logging were significant only at buffer widths of <30 m. Minimum buffer widths for eliminating logging impacts on stream habitats and biota are discussed.

Codes: experi multi reach quant ripar substrate wtemp trophic

Debowski, P., and E. Beall. 1995. Influence of dewatering on movements and distribution of salmon parr (Salmo salar L.) in relation to habitat characteristics in an experimental stream. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 267-275 p.

The response of Atlantic salmon parr to major decreases in water ievels, typical summer low flows, is not well documented. Three experiments were conducted in an artificial stream designed with sequences of riffle, flat, and pool habitat, each habitat in a section 10 m long by 3 m wide. In deeper water, parr did not respond to water level or flow decrease. In shallow water, they reduced activity, particularly feeding, and in critical conditions a portion of the population moved into deeper water. The remainder of the parr buried themselves into the gravel. After flow increase, some of the downstream moving parr returned to the riffle habitat.

Codes: enclos reach habitat quant migrat hydro

Debowski, P., and G. Radtke. 1998. Density and growth of young brown trout (Salmo trutta L.) in streams of northern Poland versus habitat attributes. Polskie Archiwum Hydrobiologii 45: 77-89.

Codes: multi habitat quant instream

Decker, A. S., J. M. Bratty, S. C. Riley, and J. Korman. 1999. Estimating standing stock of juvenile coho salmon (Oncorhynchus kisutch) and cutthroat trout (O. clarki) in a small stream: a comparison of sampling designs. method design quant.

We estimated standing stocks of juvenile coho salmon (Onchorynchus kisutch) and cutthroat trout (O. clarki) in a small stream during the fall, and used observed and simulated standing stock estimates to compare the precision and cost effectiveness of alternate sampling designs. Overall, a whole-stream mark-recapture approach produced the most precise coho standing stock estimate, but results were probably biased and the method would not be cost effective in most typical streams. Among removal methods, a stratified random sampling design (stratified by habitat type and reach) produced the most precise and cost effective estimates of coho standing stock. The most precise estimates of cutthroat standing stock, however, were produced by a proportional sampling design because cutthroat were distributed more evenly among habitat types. Simulations suggest that sampling approximately 7 percent of the habitat units in the stream was sufficient to provide a precise (CV = 0.1) estimate of coho standing stock using a stratified random sampling design. This result is specific to the study stream and further research is necessary to determine if it applies to other streams. The use of a calibrated one-pass sampling design (single pass capture totals were calibrated with 3-pass removal estimates) with stratified random sampling was marginally more cost-effective than a stratified random design where three-pass removal population estimation was carried out at all sites. Our results show that calibrated one-pass sampling with block nets can provide a reasonable index of coho abundance. However, one-pass estimates made without block nets may be biased, and installing blocknets may make this design relatively less cost-effective. If quantitative population data are required for juvenile soho stock assessment in British Coumbia, we recommend a stratified random sampling design in place of the current representative index site program.

Codes: method design quant

Deegan, L. A., B. J. Peterson, H. Golden, C. C. McIvor, and M. C. Miller. 1997. Effects of fish density and river fertilization on algal standing stocks, invertebrate communities, and fish production in an arctic river. Canadian Journal of Fisheries and Aquatic Sciences 54: 269-283.

This study examines the relative importance of bottom-up and top-down controls of an arctic stream food web by simultaneous manipulation of the top predator and nutrient availability. A two-step trophic system (algal to insects) was created by removal of the top predator (Arctic grayling, Thymallus arcticus) in fertilized and control stream reaches. Fish abundance was also increased 10 times to examine the effect of high fish density on stream ecosystem dynamics and fish. The response was measured of epilithic algae, benthic and drifting insects, and fish to nutrient enrichment and to changes in fish density. Insect grazers had little effect on algae and fish had little effect on insects. In both the control and fertilized reaches, fish growth, energy storage, and reproductive response of females declined with increased fish density. Fish growth and energy storage were more closely correlated with per capita insect availability than with per capita algal standing stock.

Codes: reach enclos trophic quant

Delacoste, M., P. Baran, F. Dauba, and A. Belaud. 1993. A study of brown trout (Salmo trutta L.) spawning macrohabitat in a French mountain stream. Evaluation of a physical habitat potential for spawning. Bulletin francais de la peche et de la pisciculture 331: 341-356.

Macrohabitat used by brown trout (Salmo trutta L.) for spawning was studied in the Neste du Louron river, in 61 morphodynamic units (pool, riffle,...) distributed in 8 reaches. These units have been characterized by physical variables (surface and bottom current velocity, depth, substrat size, water gradient, discharge) and by biological variables (trout density and biomass, trout redds density). Results showed that, at a morphodynamic unit scale, there are no correlation between redds density and trout density and biomass in this morphodynamic unit, depth variables, width of unit. There are high correlations between redds density and the percentage of bottom area with gravel suitable for spawning (0.2-5 cm), substrat size, current velocity variables, flow/width variable, water gradient. At a reach scale, there are significant correlations between redds density and trout density and biomass. A statistical relation has been assessed from multiparametric regression, and from a sample of 41 morphodynamic units randomly chosen. It uses 4 variables and explains 87% of the redds density. This relation has then been validated on another sample of 20 morphodynamic units. Some applications from these relations are briefly discussed.

Codes: reach habitat spawn quant instream foreign

Delacoste, M., P. Baran, S. Lek, and J. M. Lascaux. 1995. Classification and key for the identification of moutain stream morphodynamic units. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 149-156 p.

The hydromorphodynamic diversity of 294 units from 15 Pyrenean mountain streams was studied. 6 main groups and 18 secondary groups could be distinguished according to a multivariate analysis. A key for the determination of morphodynamic units in mountain streams is proposed. Five successive quantitative or qualitative discrimination levels aliow the determination of 18 types of units. The variability of the biological characteristics of these 18 groups has been tested for trout and redd abundance. These 18 groups explain 45.6 % of the total trout biomass variability, and 18.8 % of the young-of-the-year trout biomass variability.

Codes: multi reach quant instream foreign

Delacoste, M., S. Lek, P. Baran, I. Dimopoulos, and J. L. Giraudel. 1996. [Neuronal model versus multiple regression that predicts trout spawning grounds]. Edited by J. Ferraris, D. Pelletier and M. J. Rochet. ORSTOM, PARIS (FRANCE), 151-156 p.

Models of habitat (deterministic or stochastic) putting in relation variables of the environment and characteristics of freshwater fish (abundance, reproduction...) are good tools for decision help. 95 models of this kind are numbered. Most of them are built by means of regression analysis. In this work, the authors compare the predictive capacity of the multiple regression and of the neuronal network (known for its capacity to deal with nonlinear relations). The values predicted by models will be compared to observed values of biological data: prevision of the density of common trouts spawning grounds (Salmo trutta L.) from 10 variables of habitat, in 6 Pyrenean rivers (SW of France).

Codes: multi reach spawn modeling instream foreign

Detenbeck, N. E., P. W. DeVore, G. J. Niemi, and A. Lima. 1992. Recovery of temperate-stream fish communities from disturbance: A review of case studies and synthesis of theory. EM 16: 33-53.

To evaluate the relative effect of autecologic factors, site-specific factors, disturbance characteristics, and community structure on the recovery of temperate-stream fish communities, we reviewed case histories for 49 sites and recorded data on 411 recovery end points. Most data were derived from studies of low-gradient third- or fourth-order temperate streams located in forested or agricultural watersheds. Species composition, species richness, and total density all recovered within one year for over 70% of systems studied. Lotic fish communities were not relient to press disturbances (e.g., mining, logging, channelization) in the absence of mitigation efforts (recovery time > 5 to > 52 yr) and in these cases recovery was limited by habitat quality.

abstract from CSA: Data on recovery rates of aquatic communities from natural and anthropogenic disturbances are necessary for establishing exceedance criteria for water quality standards and for testing current ecological theory. To evaluate the relative effect of autecologic factors, site-specific factors, disturbance characteristics, and community structure on the recovery of temperate-stream fish communities, the case histories of 49 sites and recorded data on 411 recovery end points were studied. Most data were derived from studies of low-gradient third-order and fourth-order temperate streams located in forested or agricultural watersheds. Species composition, species richness, and total density all recovered within one year for over 70% of systems studied. Lotic fish communities were not resilient to press disturbances in the absence of mitigation efforts and in these cases recovery was limited by habitat quality. Following pulse disturbances, autecological factors, site-specific factors, and disturbance-specific factors all affected rates of recovery. Centrarchids and minnows were most resilient to disturbance, whereas salmonid populations were least resilient of all families considered. Species within rock-substrate/nest-spawning guilds required significantly longer time periods to either recolonize or reestablish predisturbance population densities than did species within other reproductive guilds. Recovery was enhanced by the presence of refugia but was delayed by barriers to migration, especially when source populations for recolonization were relatively distant. Median population recovery times for systems in which disturbance occurred during or immediately prior to spawning were significantly less than median recovery times for systems in which disturbances occurred immediately after spawning. There was little evidence for the influence of biotic interactions on recovery rates. (Mertz-PTT) 35 054227003.

Codes: review multi quant noenv temporal

Dewberry, C., P. Burns, and L. Hood. 1998. After the Flood. The Effects of the Storms of 1996 on a Creek Restoration Project in Oregon. Restoration & Management Notes [Restor. Manage. Notes] 16: 174-182.

Floods can have a major effect on Pacific salmon populations in a watershed. Major storms create debris-torrents (land-slides of soil, gravel, logs, trees, and boulders) that move down tributary stream channels where they under-cut and fell riparian trees; create, destroy, and move log jams; carve new stream channels on the valley floor; and both destroy and create valley habitat for aquatic organisms. In healthy watersheds, the immediate effects of floods on Pacific salmon may be minimal or short-lived, and in the long term have positive effects. In degraded watersheds, the effects can be devastating on Pacific salmon populations in both the short and long term. The effects of floods should be a major concern for any restoration project in the Pacific Northwest.

Codes: reach qual hydro ripar

Dolloff, C. A. 1986. Effects of Stream Cleaning on Juvenile Coho Salmon and Dolly Varden in Southeast Alaska. TAFS 115: 743-755.

The effects are described of selective removal of woody debris on populations of juvenile coho salmon Oncorhynchus kisutch and Dolly Varden Salvelinus malma in two small streams on Prince of Wales Island, Alaska, during the summers of 1979-1981. These streams contained debris left when surrounding forests were clear-cut in the late 1960s. Debris smaller than 60 mm in diameter and larger debris not embedded in the stream channel were manually removed from half of the study reach on each stream in 1979 by state-of-the-art techniques. Immigration and emigration of fish from the study sections and intrastream movements were very limited after an initial period of population adjustment in the spring regardless of treatment. Population densities and production of both species were typically higher in sections where debris accumulations had not been removed. Production of age-0+ and age-1+ coho salmon and age-1+ and age-2+ Dolly Varden during the June-September period ranged from 0.70 to 2.22 g/sq m in the cleaned sections and from 0.84 to 2.10 g/sq m in the uncleaned sections. Carrying capacities for both species were lower in cleaned sections despite the use of selective techniques for removing woody debris. (Author 's abstract).

Codes: multi experi reach quant lwd

Dolloff, C. A. 1987. Seasonal population characteristics and habitat use by juvenile coho salmon in a small southeast Alaska stream. Transactions of the American Fisheries Society 116: 829-838.

The density, growth, production, and movements of juvenile coho salmon Oncorhynchus kisutch from a wild population were evaluated after the fish were transplanted into five types of habitat (clear-cut, forest, meadow, slough tributary, forest tributary) in a small southeastern Alaska stream. Instantaneous growth ranged from 0.0066 in the clear-cut habitat to 0.0055 in the slough tributary. Daily increase in fork length was about 0.10 mm/d system-wide. Annual production of coho salmon in each habitat type was: meadow, 3.32 g/m super(2); slough tributary, 2.47 g/m super(2); clear-cut, 1.75 g/m super(2); forest, 1.59 g/m super(2); and forest tributary, 1.34 g/m super(2). During all sampling periods, most fish were recaptured at the site where they were released; those fish that moved neither selected nor avoided specific habitat types.

Codes: experi reach quant ripar

Dunham, J. B., and G. L. Vinyard. 1997. Incorporating stream level variability into analyses of site level fish habitat relationships: some cautionary examples. Transactions of the American Fisheries Society 126: 323-329.

Codes: multi reach segment instream warning

Dunham, J. B., and G. L. Vinyard. 1997. Relationships between body-mass, population density, and the self-thinning rule in stream-living salmonids. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa 54: 1025-1030.

Codes: multi reach quant popdyn noenv temporal

Eaglin, G. S., and W. A. Hubert. 1993. Effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 13: 844-846.

We examined the influence of logging and road construction on substrate and standing stocks of trout (Salvelinus and Salmo) in 28 stream reaches in the Medicine Bow National Forest, Wyoming. The extent to which roads crossed watercourses (culvert density) within a drainage and the proportion of the drainage that was logged were positively correlated to both the amount of fine substrate and embeddedness. Trout standing stocks had a negative relation with the density of culverts. Erosion of soil from road surfaces, ditches, and disturbed areas adjacent to roads that subsequently is deposited in stream channels seems to be an important mechanism by which logging has affected stream habitat.

Codes: multi reach quant lulc substrate

Ebel, W. J. 1985. Review of Effects of Environmental Degradation on the Freshwater Stages of Anadromous Fish. Pages 62-69. Habitat Modification and Freshwater Fisheries. Proceedings of a Symposium of the European Inland Fisheries Advisory Commission. May 23-25. Aarhus, Sweden. Butterworths, London, England.

Early research efforts begun in the 1950s and continued to the present to address the problems of environmental degradation on anadromous fish were centered mainly on fish behavioral work designed to provide solutions to fish passage problems. Information leading to solutions to passage problems for both adult and juvenile salmonids caused by dams and impoundments in the Columbia River was the highest priority of this research. Research on various fisheries enhancement measures was also begun in the late 1960s to increase production of Columbia River salmon. Some conclusions drawn from the study are: (1) Velocities in adult fish passage facilities should fall within the range of 2.4-4.0 m/s for optimum passage of salmonids; (2) Use of electrical guidance systems to divert fish from turbines or into bypass flumes or traps in rivers was effective under controlled conditions, but was impractical for operational field applications; (3) Use of water and air jets, sound, and lights to guide juvenile migrants were effective only under limited and controlled environmental conditions; (4) Travelling screens, suspended at an angle to the stream flow, were effective in flumes or irrigation canals for guiding juvenile migrants, but costs and engineering problems preclude their use at dams or large streams; (5) Adult passage of anadromous salmonids through both large and small reservoirs was not a serious problem in reservoirs studied on the Columbia River, except during periods of high water temperature; (6) Juvenile migrants were adversely affected by the impoundments on the Columbia River, which caused substantial delays in migration. These delays, coupled with changed environmental conditions in the river, caused substantial mortality to juvenile migrants which was as high as 95% in the Columbia River during low flow periods; and (7) Studies of the effect of water temperatures and supersaturation of atmospheric gas on salmonids led to the establishment of water temperature and atmospheric gas standards for the Columbia River. Any increase in temperature above 17-20 C or increase in atmospheric gas above 110% of the air-saturation value was considered detrimental to fish in the Columbia River. (See also W87-09036) (Lantz-PTT).

Codes: review qual migrat instream lakehydro

Ebersole, J. L., W. J. Liss, and C. A. Frissell. 2001. Relationship between stream temperature, thermal refugia and rainbow trout Oncorhynchus mykiss abundance in arid-land streams in the northwestern United States. Ecology of Freshwater Fish 10: 1-10.

Warm stream temperatures may effectively limit the distribution and abundance of Pacific salmon Oncorhynchus spp. in streams. The role of cold thermal refugia created by upwelling groundwater in mediating this effect has been hypothesized but not quantitatively described. Between June 21 and September 15, 1994, rainbow trout O. mykiss abundance within 12 northeast Oregon (USA) stream reaches was inversely correlated with mean ambient maximum stream temperatures ($r=-0.7$, $P<0.05$). Some rainbow trout used thermal refugia (1-10 m2 surface area) that were on average 3-8[degree]C colder than ambient stream temperatures. Within the warmest reaches, high ambient stream temperatures (>22[degree]C) persisted from mid-June through August, and on average 10-40% of rainbow trout were observed within thermal refugia during periods of midday maximum stream temperatures. Frequency of cold-water patches within reaches was not significantly associated with rainbow trout density after accounting for the influence of ambient stream temperature (P=0.06; extra sum of squares F-test). Given prolonged high ambient stream temperatures in some reaches, the thermal refugia available in the streams we examined may be too small and too infrequent to sustain high densities of rainbow trout. However, these refugia could allow some rainbow trout to persist, although at low densities, in warm stream reaches.

Codes: multi reach quant wtemp

Edwards, E. D., and A. D. Huryn. 1996. Effect of riparian land use on contributions of terrestrial invertebrates to streams. Hydrobiologia 337: 151-159.

Since terrestrial invertebrates are often consumed by stream fishes, land-use practices that influence the input of terrestrial invertebrates to streams are predicted to have consequences for fish production. We studied the effect of riparian land-use regime on terrestrial invertebrate inputs by estimating the biomass, abundance and taxonomic richness of terrestrial invertebrate drift from 15 streams draining catchments with three different riparian land-use regimes and vegetation types: intensive grazing - exotic pasture grasses (4 streams), extensive grazing - native tussock grasses (6 streams), reserve - native forest (5 streams). Terrestrial invertebrate drift was sampled from replicated stream reaches enclosed by two 1 mm mesh drift nets that spanned the entire channel. The mean biomass of terrestrial invertebrates that entered tussock grassland (12 mg ash-free dry mass/m super(2)/d) and forest streams (6 mg AFDM/m super(2)/d) was not significantly different (p > 0.05). However, biomass estimated for tussock grassland and forest streams was significantly higher than biomass that entered pasture streams (1 mg AFDM/m super(2)/d). Mean abundance and richness of drifting terrestrial invertebrates was not significantly different among land-use types. Winged insects contributed more biomass than wingless invertebrates to both pasture and tussock grassland streams. Winged and wingless invertebrates contributed equally to biomass entering forest streams. Land use was a useful variable explaining landscape-level patterns of terrestrial invertebrate input for New Zealand streams. Evidence from this study suggests that riparian land-use regime will have important influences on the availability of terrestrial invertebrates to stream fishes. Codes: reach multi graz ripar trophic nofishEifert, W. H. 1982. The Selection of Fishery Parameters for Inclusion in the Stream Reach Inventory and Channel Stability Index. An ocular watershed evaluation methodology, entitled Stream Reach Inventory and Channel Stability Index (SRICSI), was designed primarily to assess the physical aspects of channel and streambank stability. The SRICSI 's value as an aquatic habitat evaluation technique was basically unknown. During the spring and summer of 1981, seventeen representative study sites on two second-order montane streams were evaluated through application of the SRICSI procedure and three aquatic habitat assessment methodologies. Salmonid population estimates were also obtained for each site. Results indicate that a significant relationship exists between SRICSI scores and both trout population estimates, and to two of the three habitat evaluation procedures. All observed correlations were negative, suggesting that as SRICSI scores increase, trout standing crops and habitat condition decreases. Of 63 habitat-related independent variables, 40 also display significant correlation to trout standing crop data. Fifteen variables were selected for possible inclusion in the SRICSI. Inclusion of those variables found compatible with the SRICSI procedure should increase its biological sensitivity, thereby broadening its use in aquatic habitat studies. (Moore-SRC).

Codes: method multi reach quant instream

Eifert, W. H., and T. A. Wesche. 1982. Evaluation of the Stream Reach Inventory and Channel Stability Index for instream habitat analysis. Report SER-82.

In 1975, the Northern Region of the U.S. Forest Service developed an ocular watershed evaluation methodology entitled "Stream Reach Inventory and Channel Stability Index" (SRICSI). Designed to assess the physical aspects of channel and streambank stability, the SRICSI's value as an aquatic habitat evaluation technique was basically unknown. During the spring and summer of 1981, 17 representative study sites on two 2nd order montane streams were evaluated through application of the SRICSI procedure and three aquatic habitat assessment methodologies.

Salmonid population estimates were also obtained for each site. Trout standing crop estimates were statistically compared to study site SRICSI scores, the results obtained from the habitat evaluation procedures, and to data collected on 63 habitat-related independent variables. Results indicate a significant relationship exists between SRICSI scores and both trout population estimates and to two of the three habitat evaluation procedures.

Codes: method multi reach quant instream

Ekloev, A. G. 1996. Effects of habitat size and species richness on anadromous brown trout, Salmo trutta L., populations. Fisheries Management and Ecology 3: 97-101.

During the last century, vegetation cover associated with stream margins has been reduced in many streams because of channelisation vegetation (Wolf 1960). There are plans to restore many of these streams. However, it is important to identify what types of streams to restore and how to best accomplish this before implementing these plans. Consequently a study was initiated to identify which factors were related to trout density in non-channelised streams. In this study, the density of migratory brown trout (Salmo trutta) populations in riffle and run habitats was measured over 2 years, in 10 streams in 1992 and in 18 streams in 1993. Seven of the sites from 1992 were also sampled in 1993. The streams were located in 10 catchment areas, within a restricted geographic and climatic region along the western and southern coast of Scania, southern Sweden, and serve as nursery areas for migratory brown trout.

Codes: multi habitat quant instream ripar

Ekloev, A. G., and L. A. Greenberg. 1998. Effects of artificial instream cover on the density of 0 + brown trout. Fisheries Management and Ecology [Fish. Manage. Ecol.] 5: 45-53.

The effect of instream cover on the density of juvenile sea trout, Salmo trutta L., in two streams in southern Sweden was studied. One of the streams, Vallkaerrabaecken, was narrow (2-3 m) and had few sympatric species, whereas the other stream, Braaan, was wider (6-8 m) and had many sympatric species. Three treatments were used: (1) addition of artificial vegetation; (2) an undisturbed control; and (3) removal of natural vegetation. Only the first two treatments were tested in Braaan, whereas all three treatments were tested in Vallkaerrabaecken. The 0 + trout density was higher in sections containing artificial vegetation than in control sections, which in turn had higher densities than sections where natural vegetation was removed. Moreover, the effect of adding artificial vegetation on trout density was most pronounced at the end of the summer. The results indicate that instream cover from submerged macrophytes may be important for maintaining high 0 + trout densities in small and medium-sized streams where other types of instream cover are in short supply.

Codes: experi reach quant instream

Ekloev, A. G., L. A. Greenberg, C. Broenmark, P. Larsson, and O. Berglund. 1998. Response of stream fish to improved water quality: a comparison between the 1960s and 1990s. Freshwater Biology 40: 771-782.

The effect of improved water quality on fish assemblages in streams in southern Sweden was assessed by comparing species composition at 161 sites and water quality at twenty-nine sites in the 1960s and the 1990s. Water quality had improved and there was an increase in the number of sites or catchments with brown trout (Salmo trutta), stone loach (Barbatula barbatula) and eel (Anguilla anguilla). The response was greatest for brown trout and was best explained by increased oxygen concentrations. The number of sites with nine-spined stickleback (Pungitius pungitius), ide (Leuciscus idus) and brook lamprey (Lampetra planeri) decreased between the 1960s and 1990s.The decrease was greatest for nine-spined stickleback and was related to the increase in sites with trout, suggesting that nine-spined stickleback may be sensitive to predation or competition. Improved water quality has led to recolonization by brown trout, probably enabling biotic interactions to play a larger role in structuring fish assemblages. Improving water quality was an effective method for rehabilitating fish populations in streams where natural colonization was possible.

Codes: multi habitat quant watqual noenv temporal

Ekloev, A. G., L. A. Greenberg, C. Bronmark, P. Larsson, and O. Berglund. 1999. Influence of water quality, habitat and species richness on brown trout populations. Journal of Fish Biology 54: 33-43.

The influence of water quality, physical habitat and species richness on the occurrence, density and size of brown trout at 216 stream sites in southern Sweden was studied. Discriminant analysis showed that the occurrence of trout at a locality was largely determined by oxygen conditions and medium-sized substrata. At localities where trout occurred, the density of 0+ trout was highest in narrow streams with high oxygen concentrations. For older trout, >0+ in age, stream size and temperature were negatively related to density. Biotic factors also appeared to affect trout density, as trout density was inversely related to abundance of predators and coexisting species. Even intraspecific competition appeared to be important as length of 0+ trout was inversely related to trout density. It is suggested that improvements of water quality may be an effective way to restore sea trout populations in southern Sweden, especially in narrow streams where smolt production has the highest potential.

Codes: multi reach quant sppinter watqual substrate instream

Elliott, J. M., and M. A. Hurley. 1998. Population regulation in adult, but not juvenile, resident trout (Salmo trutta) in a Lake District stream. Journal of Animal Ecology 67: 280-286.

Unlike a neighbouring sea-trout population that showed strong density-dependent survival, a resident trout population (Salmo trutta L.) showed simple proportionate survival in the early life-stages. However, this persistent population fluctuated within narrow limits. Mature adults, especially during spawning, were the only possible life-stage left in which regulation might occur. 2. An October census, just prior to spawning, was made at five sites (total area 300 m super(2)) from 1965 to 1983. Gravel nests (redds) associated with females of known size were excavated outside these sites to obtain a power-function relationship between egg density per redd and female length (range 181-280 mm, n = 26). This relationship and the census data for females (range 186-284 mm) were used to estimate egg densities in each year-class. 3. The census data for the early life-stages (0+, 1+, 2+ trout) confirmed proportionate survival with no evidence for density-dependent regulation. In contrast, the number of spawning females produced in each year-class was strongly density dependent on the initial number of females that laid eggs at the start of the year-class. Similarly, total egg production in each year-class was density dependent on initial egg density. 4 Both relationships were well described by the Ricker and Beverton-Holt stock-recruitment models ($P < 0.001$) and the goodness-of-fit was similar for both models. This study is probably the first to provide clear evidence for fish population regulation in the adult, rather than the juvenile, stage.

Codes: quant popdyn spawn noenv temporal

Elliott, S. T. 1986. Reduction of a Dolly Varden population and macrobenthos after removal of logging debris. Transactions of the American Fisheries Society 115: 392-400.

Logging debris resident for five or more years in small streams of southeastern Alaska is frequently removed to improve salmonid habitat. This practice was evaluated for its effects on juvenile anadromous Dolly Varden Salvelinus malma and macrobenthos populations in a small spring-fed stream during 1973-1981. Debris, consisting of limbs, needles, and fragmented logs, was removed by hand from the entire stream in July 1976. The surface area, number, and size of pools was reduced thereafter, and the water velocity increased. Macrobenthos density and invertebrate drift decreased 60-90% immediately after debris removal but returned to pretreatment levels in 1977. The Dolly Varden pouplation decreased from 900 to less than 100 fish by 1978 and then fluctuated sharply between late 1978 and 1981. Removal of old logging debris does not improve habitat and can result in smaller rearing populations. Old debris should not be removed unless a block to migrating adult spawners or impairment of water quality can be demonstrated.

Codes: experi reach quant lwd temporal

Elso, J. I., and P. S. Giller. 2001. Physical characteristics influencing the utilization of pools by brown trout in an afforested catchment in Southern Ireland. Journal of Fish Biology [J. Fish Biol.] 58: 201-221.

Seasonal and spatial variation in brown trout Salmo trutta L. abundance, density and biomass were studied in 29 pools of varying size in an afforested catchment together with the physical characteristics of those pools. A movement of 0+ trout towards the pools as the year progresses was detected. Water volume of the pool accounted for a significant amount of the variation in metrics across all seasons. Cover provided by overhanging vegetation also explained a significant amount of variation, especially during the summer. Water velocity, percentage of undercut bank and substrate composition had little explanatory power in the distribution of trout in the pools. In all seasons significant relationships between both fish biomass (g m super(-2)) and fish number and water volume in the pool were found. However, in summer and autumn there was also a significant correlation between both fish density (fish m super(-2)) and biomass and water volume in the pool described by a power function with a coefficient >1. These relationships were consistent across the subset of pools studied over a 2-year period. Thus there was a proportionally greater number of fish in deeper pools than in the shallower ones in summer and autumn, suggesting that trout use the available habitat (i.e. the pool) as a three dimensional space in which an increase in the third dimension (depth) leads to a proportionally greater number of fish per unit area.

Codes: multi habitat quant migrat instream

Emlen, J. M. 1995. Population viability of the Snake River chinook salmon (Oncorhynchus tshawytscha). Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa 52: 1442-1448.

In the presence of historical data, population viability models of intermediate complexity can be parameterized and utilized to project the consequences of various management actions for endangered species. A general stochastic population dynamics model with density feedback, age structure, and autocorrelated environmental fluctuations was constructed and parameterized for best fit over 36 years of spring chinook salmon (Oncorhynchus tshawytscha) redd count data in five Idaho index streams. Simulations indicate that persistence of the Snake River spring chinook salmon population depends primarily on density-independent mortality. Improvement of rearing habitat, predator control, reduced fishing pressure, and improved dam passage all would alleviate density-independent mortality.

Codes: multi modeling spawn popdyn temporal

Erman, D. C., and D. Mahoney. 1983. Recovery After Logging in Streams With and Without Bufferstrips in Northern California.

The impact of logging on aquatic resources involves a reduction in nearstream vegetation and disturbance of the land surface. This frequently leads to elevated sediment loads, increased water temperature, disruption of aquatic food webs, and decreased habitat diverstiy. In some cases logging has resulted in greater diversity and biomass of young salmonids. Six logged sites, six narrow-buffered sites, and 17 controlled sites were sampled from 25 streams grouped into nine blocks in northern California. The samples were taken 6-10 years after logging and 5 or 6 years after an initial postlogging study in order to evaluate recovery rates. Unbuffered streams showed considerable but incomplete recovery based on a diversity index of macroinvertebrates. Compared to the mean of control streams, the mean diversity of logged streams was 9.1% lower in 1980-81 versus 25.2% lower in 1975. Narrow-buffered streams, by contrast, changed little since the last survey. The mean diversity was 12.5% lower than controls in 1980, compared to 12.4% in 1975. The six streams showed a positive association between buffer width and diversity index. By employing a measure of transportable sediment stored in the stream bed, it was found that the logged and narrow-buffered streams still contained significantly more fine sediment than comparable control streams. Narrow buffers were not effective in promoting a more complete or rapid rate of recovery than streams without buffers. A few taxa had higher density in stations with more fine sediment, and, as a result, the diversity index was lower in those stations. (Garrison-Omniplan).

Codes: multi experi qual nofish? reach ripar

Everest, F. H., and W. R. Meehan. 1981. Forest Management and Anadromous Fish Habitat Productivity.

The anadromous fishery resources of western North American are produced largely within forested watersheds. Forest and rangeland management activities that can influence the quality of anadromous fish habitat include timber harvest, road construction, and livestock grazing. Organic debris from forested watersheds of the Pacific Northwest and Alaska enters streams through direct litterfall, landslides, debris torrents, timber felling, and streambank erosion, plus blowdown of trees and branches. Large woody debris can create habitat for rearing salmonids, but may cause sedimentation in spawning areas. Large, naturally occurring debris can promote streambank stability and reduce streambed scour. Large accumulations of fine organic debris can adversely affect habitat by reducing dissolved oxygen and producing toxic leachates. Total removal of debris can result in a completely open channel, promoting streambed sour, steambank instability, and loss of fish habitat productivity. Debris torrents, a common mass erosion event in the Pacific Northwest, have a negative impact on habitat and production of anadromous salmonids in small streams immediately downstream from the torrent egress. Studies within a 1-mile reach of Knowles Creek, however, indicate that the total effect of debris torrents in that sediment-poor watershed tends to be positive. Preliminary results of a livestock grazing study do not show profound effects on fish populations among various grazing systems or between one to three years of season-long grazing and ungrazed controls. (Moore-SRC).

Codes: reach instream substrate lwd quant?

Everest, F. H., J. R. Sedell, G. H. Reeves, and M. D. Bryant. 1991. Planning and evaluating habitat projects for anadromous salmonids. Edited by J. Colt and R. J. Whilte. AFS, BETHESDA, MD. 68-77 p.

To improve habitat in a stream system, planning, implementing, and evaluating improvements must address the appropriate spatial and temporal scales, including (1) subbasin inventory information for all seasons of the year--a departure from the usual site or reach inventory normally done during summer, (2) a thorough analysis of factors limiting fish production in the subbasin during all seasons of the year, (3) identification of improvement techniques that address limiting factors, and (4) selection of sites for habitat projects in the basin. Items (1) and (2) are usually done by fishery biologists; items (3) and (4) are more interdisciplinary, thereby requiring skills of both biologists and hydraulic engineers. The evaluation of habitat projects encompasses physical, biological, and economic aspects that must be placed in an appropriate spatial and temporal context. This paper proposes a sequential process for planning and evaluating habitat improvement projects, and discusses examples from northwest Oregon and southeast Alaska.

Codes: experi design reach quant

Everest, F. H., J. R. Sedell, G. H. Reeves, and J. Wolfe. 1985. Fisheries enhancement in the Fish Creek Basin: An evaluation of in-channel and off-channel projects, 1984. Annual report 1984. Report DOE/BP/16726-1.

Construction and evaluation of salmonid habitat improvements on Fish Creek, a tributary of the upper Clakamas River, was continued in fiscal year 1984. Habitat improvement work in the basin is designed to increase the annual number of chinook, coho, and steelhead smolt outmigrants from the basin. The primary objectives include: (1) evaluation and quantification of changes in salmonid spawning and rearing habitat resulting from a variety of habitat improvements; (2) evaluation and quantification of changes in fish populations and biomass resulting from habitat improvements; and (3) evaluation of the cost-effectiveness of habitat improvements developed with BPA and KV funds on Fish Creek. (DBO).

Codes: experi design reach quant

Fausch, K. D., C. Gowan, A. D. Richmond, and S. C. Riley. 1995. The role of dispersal in trout population response to habitat formed by large woody debris in Colorado mountain streams. Bulletin francais de la peche et de la pisciculture 337-339: 179-190.

Fishery managers commonly use logs to create pool habitat for salmonids in mountain streams throughout the world, often to compensate for a lack of natural large woody debris (LWD) due to deforestation or other disturbances in riparian forests. Measurements of LWD in 11 Colorado mountain streams that drain patches of old-growth spruce-fir (Picea-Abies) forest indicated that most pools were formed by LWD. These pool-forming pieces were, on average, larger than pieces that did not form pools. The majority spanned the channel perpendicular to flow and formed plunge and dammed pools. Fishery managers that use perpendicular logs to form pools generally assume that the added habitat will increase survival of resident salmonids during critical periods such as winter. Results of a long-term experiment to test this hypothesis in six Colorado mountain streams showed that resident trout populations increased rapidly and significantly in 250-m treatment sections versus adjacent controls. However, recaptures of marked trout and direct trapping to measure dispersal indicated that the pool-forming logs increased adult trout populations primarily by inducing fish that were moving to remain in the treatment sections, rather than by increasing in situ overwinter survival as reported by others. Research and management of resident stream salmonids has been guided by the restricted movement paradigm, which states that most adult fish are relatively sedentary. However, analysis of previous movement studies revealed that most investigators focused only on fish recaptured in the reaches where they were released, a critical design flaw that causes a bias against detecting movement. Substantial fish movement has important implications for habitat enhancement and restoration, and calls for a watershed management approach.

Codes: experi multi reach quant migrat instream lwd warning

Fausch, K. D., C. L. Hawkes, and M. G. Parsons. 1988. Models that predict standing crop of stream fish from habitat variables: 1950-85. General Technical Report PNW-GTR-213. United States Department of Agriculture Forest Service.

Codes: review reach habitat quant instream ripar lulc warning

Fausch, K. D., and R. J. White. 1981. Competition between brook trout (Salvelinus fontinalis) and brown trout (Salmo trutta) for positions in a Michigan stream. CJFAS 38: 1220-1227.

Competition between brook trout (Salvelinus bontinalis) and brown trout (Salmo trutta) was studied by measuring characteristics of daytime positions held by brook trout before and after studied by measuring characteristics of daytime positions held by brook trout before and after removalof the brown trout from 1800 m of a stream. After brown trout removal, brook trout larger than 15 cm chose resting positions with more favorable water velocity characteristics and more often in shade. The position shift was greatest for the largest brook trout, those of 20-30 cm. Feeding positions of brook trout changed little upon brown trout removal according to our criteria. The shift in resting positions of brook trout after release from competition with brown trout indicates that brown trout excluded brook trout from preferred resting positions, a critical and scarce resource. The combined effects of such interspecific competition, differential susceptibility to angling, differential response to environmental factors, and predation of brown trout on juvenile brook trout may account for declines of brook trout populations while brown trout populations expand in many streams of the northeastern United States where the two species are sympatric.

Codes: qual reach microhab sppinter instream

Fjellheim, A., and G. G. Raddum. 1996. Weir building in a regulated west Norwegian river: Long-term dynamics of invertebrates and fish. Edited by J. E. Brittain, I. Brinkman and C. Nilsson. 501-508 p.

In the period 1975-1990 long-term studies of succession and dynamics of invertebrates and fish were conducted in a weir basin area in the strongly regulated River Ekso. During the years of the study, the invertebrate community in the basin was subjected to great changes. In the first years after weir building, biomass was greatest in the riffles due to a higher abundance of lotic species like the mayfly, Baetis, blackflies and many stonefly larvae. The biomass of oligochaetes and chironomids was similar both in the riffles and in the deeper and more lentic weir basin. In the following years the biomass of lentic chironomid species increased dramatically in the basin. In 1984 the fauna was dominated by Stictochironomus pictulus. In 1988 another species, Chironomus melanotus, also became very abundant. At this time net benthic animal production in the basin had increased 10-fold compared with 1975-1976. A high flow situation during the summer of 1989 altered the weir basin community dramatically. The mean autumnal biomass decreased 4.5 times compared with 1988, dominant lentic species disappeared and lotic/semi-lotic species like the stoneflies Amphinemura sulcicollis, Leuctra fusca and Capnia pygmaea increased in density. Prior to regulation the density of brown trout in the riffle, which later constituted the weir basin area, was 2.5 individuals 100 m super(-2). During the first years after regulation and weir building, fish density increased to 11.1. In 1983 a density of 23.0 trout 100 m super(-2) was achieved. The trout were stunted and showed marked tendencies towards food depletion. During 1984-1985 most of the brown trout population of the basin were removed and used as stock material in the reservoirs of the hydropower station. This resulted in a higher growth rate in the remaining weir basin population. The strong reduction in trout density was followed by major immigration of small (2+ and 3+) trout from the surrounding riffles to the basin. The trout population was now harvested, while a small population of adult spawners was retained. Weir basins increase the area of pool habitats in strongly regulated rivers, and are of major benefit for trout populations, especially by segregating size classes and increasing winter survival. The presence of intermittent riffle sections is also very important, both as spawning and nursery areas and for fish food production.

Codes: experi quant trophic temporal

Ford, J. E., and D. G. Lonzarich. 2000. Over-winter Survival and Habitat Use by Juvenile Coho Salmon (Oncorhynchus kisutch) in Two Lake Superior Tributaries. Journal of Great Lakes Research [J. Great Lakes Res.] 26: 94-101.

Dramatic declines in commercial and recreational fisheries for coho salmon (Oncorhynchus kisutch) in Lake Superior have raised questions about the natural factors that limit their productivity. Snorkelingsurveys were conducted during the winters of 1995-96 and 1996-97 to estimate over-winter mortality and determine winter habitat use by juvenile coho salmon in two spring-fed tributaries of Chequamagon Bay, Lake Superior. Results indicated high densities of juvenile coho salmon in pool habitats of the two streams (x = 0.85 fish/m super(2)) and high over-winter survival (> 45%). Regression analyses revealed no significant relationships between fish distribution and physical habitat variables (large woody debris, overhead cover, and pool size). No shift in habitat use over the winter was found. These results contrast sharply with findings from the Pacific Northwest where juvenile coho salmon generally occupy complex pool habitats during the winter. Although streams of the Great Lakes region are similar in many respects to Pacific streams, differences, particularly in stream flow regimes, indicate that the early life history of coho salmon populations in these two regions differ dramatically. These observations may have important implications on the management of stream habitats in the Great Lakes.

Codes: multi habitat quant instream lwd warning

Fraidenburg, M. E., and R. H. Lincoln. 1985. Wild chinook salmon management: an international conservation challenge. North American Journal of Fisheries Management 5: 311-329.

The complexity of managing wild chinook salmon (Oncorhynchus tshawytscha) stocks arises primarily from marine migrations across political boundaries, the currently seriously overfished condition of stocks along the North

American Pacific Coast, and detrimental impacts from activities of competing users of the freshwater habitat. Despite the fact that data and analytical capabilities are adequate, many chinook salmon stocks continue to decline. This is happening because consistent management standards are lacking or not applied by decision-making bodies in favor of various unquantified socio-political alternatives. Yielding to socio-political pressures occurs even at the biological staff level, resulting in compromised biological recommendations that further undermine the fundamental management goal of long-term stock health and viability. We describe three chinook salmon case histories as paradigms of the problem: (1) the Georgia Strait stock where managers have failed to apply management standards aimed at increasing spawning escapements; (2) the Klamath River stock where managers have applied situational management standards which continuously compromise or ignore spawning escapement objectives; and (3) the upper Columbia River "bright"stock where conditional standards are being applied by numerous regulatory entities placing spawning escapement needs at a lower priority than other considerations.

Codes: philosphy

Friesen, T. A., and D. L. Ward. 1996. Status and condition of fish assemblages in streams of the Tualatin River Basin, Oregon. Northwest Science 70: 120-131.

We conducted fish inventories at 38 sites on fifteen streams of the lower Tualatin River Basin as part of a study to document fish species and assess the impacts of urbanization on native fish assemblages. We used three-pass electrofishing techniques to survey each site in spring, summer, autumn, and winter. We collected 25 species of fish from ten families; twelve species from five families (6.3% of the total catch) were exotic to Oregon. Reticulate sculpin Cottus perplexus, a native fish tolerant of habitat degradation, comprised 68.4% of the catch. Number of species per stream ranged from 5 to 15; number of native species ranged from 4 to 10. Sites in the upper sections of streams contained the largest number of trout, native minnows, and sculpins, whereas lower sites contained more diverse species assemblages and a larger number of introduced fish. We found a significant difference in the number of native species among sites of different stream order, but no significant difference when all species were considered. Our catch also varied seasonally, likely due to species motility, gear selection, and variation in life history stages. Native species intolerant to habitat disturbances (torrent sculpin Cottus rhotheus and Oncorhynchus spp.) comprised only 1.7% of the total catch, and 2.0% of the total catch exhibited parasites or physical anomalies. The relatively low number of intolerant species, high proportion of fish with parasites or anomalies at some sites, introduction of exotic species, and reported habitat deficiencies suggest that native fish assemblages in the basin are at least moderately unhealthy.

Codes: multi reach quant instream

Garcia de Jalon, D., M. Mayo, and M. C. Molles. 1996. Characterization of Spanish Pyrenean stream habitat: relationships between fish communities and their habitat. Regulated Rivers Research & Management 12: 305-316.

Spanish Pyrenean streams are characterized by extreme summer drought and torrential flows during spring snowmelt and their fish communities are dominated by trout at high altitudes and by barbel in the lower reaches. The Instream Flow Incremental Methodology (IFIM) was adapted to analyse the fisheries habitat of Spanish streams. Parameters were developed that measure the particular characteristics of these streams, taking into account the habitat needs of the main developmental stages (adults, juveniles, fry and spawning) in different seasons. For this analysis 'potential habitat' was defined as that determined by hydraulics and geomorphological features. 'Real habitat used' was defined by the fish population characteristics (densities, biomass, age-structure and population dynamics). Habitat complexity was calculated as the diversity of habitats of different developmental stages and different species. Habitat conditions during summer-drought were analysed by the simulation of low flow conditions as measured by gauging stations. Habitat parameters were measured in several stream reaches and compared with the characteristics of the fish populations they supported by multivariate analysis. The results show that fish abundance increases downstream along the river continuum, indicating that the habitat carrying capacity increases downstream. The depth and rock surfaces are the main factors limiting the capacity of the stream to provide refuges. Trout populations are also influenced by submerged macrophytes. This IFIM evaluation of stream habitat was not correlated with fisheries features because factors other than hydraulics appear to limit trout population in the Pyrenean study streams. Hydraulic factors may limit the fish populations during brief periods, but population recovery from these disturbances may take longer than the time available between disturbances events.

Codes: multi reach quant microhab instream ifim warning hem

Giannico, G. R. 2000. Habitat selection by juvenile coho salmon in response to food and woody debris manipulations in suburban and rural stream sections. CJFAS 57: 1804-1813.

This study explored the effects of food and woody debris manipulations on the summer distribution of juvenile coho salmon (Oncorhynchus kisutch) in small suburban streams. To examine fish responses to these factors, three different experiments were carried out in modified sections of two streams. The results showed that the distribution of juvenile coho salmon in a stream section was primarily controlled by the availability and distribution of food among pools and by the presence and density of woody debris. Food, however, played a dominant role because the foraging quality of a pool not only affected the density of fish in it but also the response of those fish towards instream debris. In food-rich stream sections, low proportions of juvenile coho salmon occupied pools with dense woody debris in the spring, which changed towards late summer. In contrast, in food-poor reaches, high proportions of fish were found in pools with abundant debris in the spring. Pools that combined abundant food with sparse woody debris were the most favoured by the fish. It is important that salmonid habitat enhancement projects consider that open foraging areas interspersed with woody debris characterize the typeof summer habitat that juvenile coho salmon prefer.

Codes: experi habitat quant lwd trophic

Giannico, G. R., and M. C. Healey. 1999. Ideal free distribution theory as a tool to examine juvenile coho salmon (Oncorhynchus kisutch) habitat choice under different conditions of food abundance and cover. Canadian Journal of Fisheries and Aquatic Sciences 56: 2362-2373.

We investigated the mechanisms affecting habitat choice by juvenile coho salmon (Oncorhynchus kisutch) in relation to the patchy distribution of food and cover. We tested the following hypotheses: (i) the distribution of juvenile coho, both between patches in a pool and between separate pools in a channel, corresponds numerically to the food input rate of those habitat patches as predicted by the "input-matching rule" of ideal free distribution (IFD) and (ii) the addition of instream cover, by increasing visual isolation among competitors, promotes input matching both within and between pools. We conducted our experimental work in artificial channels and we used two different types of cover, instream and overhead. In the absence of cover and with either no differences or relatively small differences in food abundance between patches, the spatial distribution of juvenile coho responded numerically to the input rate of food as predicted by the IFD. However, when differences in food abundance between patches were relatively large or cover was present, fish distributions consistently undermatched food input rate in the rich patch. Coho foraged in open patches away from cover within single pools but preferred pools with cover when choosing between separate pools. Several IFD models were used to examine the observed dispersion patterns.

Codes: experi enclos habitat quant trophic ripar instream

Gibson, R. J. 1988. Mechanisms regulating species composition, population structure, and production of stream salmonids; A review. Polskie Archiwum Hydrobiologii/Polish Archives of Hydrobiology 35: 469-495.

Streams supporting salmonids are characterized by riffles and pools, with the success of a species depending on the availability of suitable habitat for the ecological needs of the different life stages of the species. Juveniles of one species may be primarily riffle dwellers, which may be anadromous, such as the Atlantic salmon, and a second species may primarily occupy the slower water and pools, such as brown trout or American brook trout. Social behavior is affected by a number of factors, including water velocity, availability of food, and temperature, so that levels of aggression can change, affecting production.

Codes: review microhab habitat sppinter instream wtemp

Gibson, R. J. 1993. The Atlantic salmon in fresh water: Spawning, rearing and production. Reviews in Fish Biology and Fisheries 3: 39-73.

Fluvial salmonids have evolved to use the diversity of habitats in natural streams for different life history stages and at different seasons. Required freshwater habitat of Atlantic salmon (Salmo salar) can be classified generally as that suitable (i) for spawning, (ii) for feeding during the major growing period, and (iii) for overwintering. Spawning habitat of salmon is usually in rapid water at the tail of pools on the upstream edge of a gravel bar, ideally with depths about 25 cm, in mean water velocities of about 30-45 cm/s, with maximum velocities about 2 body lengths/s, and with a substrate of irregularly shaped stones of cobble, pebble, and gravel. Underyearling salmon (< 7 cm TL) are most common in shallow (< 15 cm) pebbly riffles, whereas older and larger parr (> 7 cm TL) are usually in riffles deeper than 20 cm with a coarse substrate. Depth preference increases with size. Multiple linear regression models quantifying parr habitat have identified substrate as an important variable, with a positive relationship to an index of coarseness. Negative relationships were found with mean stream width, range of discharge, and overhanging cover. Water chemistry, especially alkalinity, nitrates, and phosphates, are important regulators of production. Although similar variables had importance, coefficients among rivers differed. Interactions occur among variables. Further studies are required to quantify productive capacity of habitat for parr. Results suggest that useful models can be derived and if a river system is mapped, and stratified by habitat, then smolt yield could be predicted and the required egg deposition could be estimated. In winter, young salmon shelter among coarse substrate or move to pools, but continue feeding, with larger parr being more active.

Codes: review multi quant habitat instream substrate

Gil, J., and M. C. Healey. 1999. Ideal free distribution theory as a tool to examine juvenile coho salmon (Onchorynchus kisutch) habitat choice under different conditions of food abundance and cover. CJFAS 56: 2362-2373.

This study investigates the mechanisms affecting habitat choice by juvenile coho salmon (Onchorynchus kisutch) in relation to the patchy distribution of food and cover. The following hypotheses were tested: 1) the distribution of juvenile coho, both between patches in a pool and between separate pools in a channel, corresponds numerically to the food input rate of those habitat patches as predicted by the "input-matching rule" of ideal free distribution (IFD) and 2) the addition of instream cover, by increasing visual isolation among competitors promotes input matching both within and between pools. Experimental work was conducted in artificial channels and two different types of cover, instream and overhead were used. In the absence of cover and with either no differences or relatively small differences in food abundance between patches, the spatial distribution of juvenile coho responded numerically to the input rate of food as predicted by the IFD. However, when differences in food abundance between patches were relatively large or cover was present, fish distributions consistently undermatched food input rate in the rich patch. Coho foraged in open patches away from cover within single pools but preferred pools with cover when choosing between separate pools. Several IFD models were used to examine the observed dispersion patterns.

Codes: experi enclos habitat quant instream ripar trophic

Gislason, G. M., J. S. Olafsson, and H. Adalsteinsson. 1998. Animal communities in Icelandic rivers in relation to catchment characteristics and water chemistry. Preliminary results. Nordic Hydrology [Nordic Hydrol.] 29: 129-148.

Catchment areas of Icelandic rivers are mostly barren or with little vegetation cover in the highlands, but with heathland and mire vegetation in the lowlands. Chemical composition and nutrient availability in Icelandic rivers are influenced by geology, topography and vegetation cover in the river basins. This seems to determine the density and diversity of benthic invertebrates, species composition of anadromous fish and catch of salmon in Icelandic rivers. Species composition of benthic communities is determined by particulate organic matter drifting downstream from river head-waters. Filter feeding blackfly larvae dominate lake outlets, while algal grazing chironomid larvae dominate rivers not influenced by lakes. In well vegetated catchment basins, lake-fed rivers have higher catches of salmon than non-lake fed rivers. Only a few of the rivers flowing from poorly vegetated areas sustain salmon. Glacial rivers have the lowest density and diversity of benthic invertebrates of all river groups and do not sustain fish populations.

Codes: reach multi ripar lakehydro qual

Glova, G. J. 1986. Interaction for food and space between experimental populations of juvenile coho salmon (Oncorhynchus kisutch) and coastal cutthroat trout (Salmo clarki) in a laboratory stream. Hydrobiologia 131: 155-168.

Populations of juvenile coho salmon (Onoorhynchus kisutch) and coastal cutthroat trout (Salmo clarki) frequently cohabit small coastal streams in western North America. When tested separately at 13 degree C, their habitat demands were similar and approximately 60-75% of either species occurred in pools. When tested together they segregated, with approximately 75% of coho in pools and up to 63% of cutthroat trout in riffles. In winter, at 3 degree C, both species preferred pools and overhead cover, whether tested separately or together. At 5 degree C, they partially segregated in a pattern similar to, but far less pronounced than, that in summer. Both species used similar forms of aggressive behaviour, although aggressive displays were more frequently used by coho, while nipping was more frequently used by cutthroat trout. Both salmonids were most aggressive when food was presented, irrespective of season, although coho responded with greater rapidity and intensity to feeding than did cutthroat trout.

Codes: experi habitat qual sppinter ripar

Glova, G. J. 1987. Comparison of allopatric cutthroat trout stocks with those sympatric with coho salmon and sculpins in small streams. biology of fishes. The Hague 20: 275-284.

Juvenile stocks of allopatric (upstream of barrier falls) cutthroat trout Salmo clarki and those sympatric (downstream of barrier falls) with coho salmon Oncorhynchus kisutch and sculpins Cottus spp., were sampled during the late summer period of low flows in six small coastal streams in British Columbia. The objective was to obtain and compare information on pattern of habitat use and fish size distribution of these two trout types. In most instances, density (n m super(-2); g m super(-2)) of cutthroat trout was considerably greater in pools and glides in the allopatric than in the sympatric stocks. The results of this study provide insight of potential impact of coho salmon juvenile transplants into stream segments supporting allopatric cutthroat trout.

Codes: multi habitat quant sppinter instream

Gortz, P. 1998. Effects of stream restoration on the macroinvertebrate community in the River Esrom, Denmark. Aquatic Conservation: Marine and Freshwater Ecosystems [Aquat. Conserv.: Mar. Freshwat. Ecosyst.] 8: 115-130.

The macroinvertebrate fauna of three restored and two reference sections in the River Esrom was compared 4 years after completion of a restoration project using gravel, boulders and stream concentrators on a 3.2-km reach in order to enhance the physical structure and natural trout spawning. Sampling was performed by standard methods (stone-, core- and kick-sampling). The faunal communities were compared by Bray-Curtis similarity, diversity (H), saprobic index (SI) and Danish fauna index (DFI) methods. Restoration with stream concentrators resulted in a deeper and narrower stream with a higher flow velocity near the bottom and a coarser substrate compared with the reference section. The fauna showed higher similarity to the fauna found on the stony bottom sections due to immigration of taxa preferring stony substrate (e.g. Lepidostoma hirtum, Theodoxus fluviatilis) and SI and DFI generally improved from II to/towards I-II. Clean-water species such as Agapetus ochripes and Limnius volckmari, were found in significantly higher numbers in the restored sections compared with the reference section. Five times as many trout spawning redds occurred in the restored sections than in the non-restored. However, electro-fishing revealed few young-of-the-year trout and did not reflect spawning success. It was concluded that attempts to improve the physical structure and spawning environment altered invertebrate composition, but did not enhance trout production.

Codes: experi qual spawn trophic

Gosse, J. C. 1985. Brown trout (Salmo trutta) responses to stream channel alterations, their microhabitat requirements, and a method for determining microhabitat in lotic systems. Dissertation.

Stream channel alterations are alleged to have detrimental effects on the stream fauna, particularly the sport fishery. Four study sites were chosen to evaluate the quantitative effects of channel alterations on a brown trout (Salmo trutta) population: (1) an unaltered control; (2) an area dredged twice during the course of the study; (3) an area bulldozed 4 years prior to study, half of which was bulldozed again during the study; (4) an area bulldozed 4 years prior to study, 400 meters of which has remained channelized and 100 meters of which has reverted to natural meandering. Population estimates were made approximately bi-monthly for at least a year in each site. Analysis of variance was used to compare among sites for average total density and biomass, and total production per interval. Dredging had less effect on the population than did bulldozing. Populations in the bulldozed sites were most severely effected in those areas that had retained the greatest degree of artificial configuration. The youngest and oldest age groups were most severely effected by stream alterations. Growth was not affected by channel alterations. A technique was developed for quantitatively defining the precise microhabitat of a stream dwelling species in situ. Scuba equipment was modified to allow observations of fish in high velocity streams and at low temperatures. An air-exhaust system prevented bubbles from disturbing the fish. A sonic transmitter-receiver allowed the diver to communicate with the surface personnel who monitored the instruments and recorded data. Brown trout microhabitat was measured by life stage (age 0, juvenile, and adult) and physical activity from summer through winter for a wide variety of stream habitats in two different river systems. Water velocity at fish location, water depth, fish depth, substrate, and overhead light appear to be the most important of the physical parameters monitored in defining brown trout microhabitat. Physical activity and life stage of the fish were vital subdivisions in defining microhabitat requirements. Trout selected specific microhabitat areas from the range of habitat available in each stream. The adverse effects observed for channel alterations can be explained in terms of microhabitat requirements (DBO).

Codes: experi reach quant microhab instream method

Gowan, C., and K. D. Fausch. 1996. Long-term demographic responses of trout populations to habitat manipulation in six Colorado streams. Ecological Applications 6: 931-946.

Fish communities in high-elevation, Rocky Mountain streams consist of only one or a few trout species, so these streams are ideal for quantifying how physical habitat manipulation influences population biology. Managers often alter habitat structure in hopes of increasing the number or size of fish in a population, but this practice has not been rigorously evaluated, and the mechanisms involved are not well understood. We measured fish abundance and habitat conditions in each half of 500-m study reaches in six streams for 2 yr before and 6 yr after installing 10 low log weirs in a randomly designated half (treatment section). Mean depth, pool volume, total cover, and the proportion of fine substrate particles in the stream bed increased in treatment sections within 1 to 2 years, whereas habitat in adjacent controls remained unchanged. Abundance and biomass of adult fish, but not juveniles, increased in treatments relative to controls in all streams. Recaptures of trout that were individually tagged and others that were batch marked revealed that immigration was primarily responsible for increased adult abundance and biomass, whereas no biologically significant differences occurred for recruitment, survival, or growth. Few (<5%) immigrants to treatment sections came from adjacent controls, indicating that the increased adult abundance did not result simply from fish redistributing within the study reach, but was caused instead by immigration from beyond the reach boundaries. Immigration to control sections was frequent as well, leading us to conclude that fish movement was common, contrary to most literature on stream trout. We also detected a high degree of concordance in fish abundance fluctuations within and among streams, suggesting that regional factors influenced fish populations over large spatial scales. Our research shows that log weirs increase trout abundance, but only if other management activities assure that fish dispersal remains unimpeded within the drainage.

Codes: multi experi reach basin quant migrat instream substrate warning

Gowan, C., and K. D. Fausch. 1996. Mobile brook trout in two high-elevation Colorado streams: re-evaluating the concept of restricted movement. Canadian Journal of Fisheries and Aquatic Sciences 53: 1370-1381.

Movements of brook trout (Salvelinus fontinalis) were studied in two high-elevation (>2700 m) Colorado streams by marking (n = 4005) and recapturing fish using weirs and electrofishing at locations spaced up to 4500 m apart. Movement was most common in the upstream direction during summer, and about equal upstream and downstream between summers. Highest rates of movement occurred during and just after runoff, and before spawning, but substantial numbers of fish moved throughout the summer. Fish captured moving through weirs tended to be longer but in poorer condition than fish captured during electrofishing in 500-m reaches between weirs (i.e., the general population). On the basis of capture histories for individual fish, 59 and 66% in the two streams moved at least 50 m (up to 3380 m), even though most could be tracked only for several months. Thus, significant proportions of fish in electrofishing samples spaced throughout the stream bore marks from locations up to 2000 m away, indicating that long-range movements were relatively common. This conclusion is contrary to most literature on resident stream salmonids. We show how methods commonly used to study movement may be seriously biased, and suggest that movement may be more widespread than currently recognized.

Codes: multi segment migrat noenv

Grant, J. W. A., J. Englert, and B. F. Bietz. 1986. Application of a method for assessing the impact of watershed practices: effects of logging on salmonid standing crops. North American Journal of Fisheries Management 6: 24-31.

Preliminary studies on three control streams (unaffected by logging) indicated that there were no significant intrastream differences in the total biomass of Atlantic salmon (Salmo salar), brown trout (Salmo trutta), and brook trout (Salvelinus fontinalis) between discrete areas of similar habitat. Therefore, total salmonid biomass should be a good indicator of stream habitat quality for salmonids and useful in assessing the impacts of watershed practices. Total salmonid biomass was used to assess the effect of logging disturbances, including stream crossings, clearcuts, and bank modification, on the salmonid populations of 10 streams in New Brunswick and Nova Scotia. This biomass was measured at pairs of logging-disturbed and upstream control areas of the 10 streams. Salmonid biomass decreased significantly downstream of two stream crossings, probably because of increased siltation, while seven clear-cuts and one bank modification along the other eight streams had no significant effect on salmonid biomass. Removal of the canopy cover was associated with increases in the fork length or weight at age, or both, of juvenile Atlantic salmon but had no consistent effect on the size at age of brook trout.

Codes: multi experi reach quant substrate ripar

Grant, J. W. A., and D. L. Kramer. 1990. Territory size as a predictor of the upper limit to population density of juvenile salmonids in streams. Canadian Journal of Fisheries and Aquatic Sciences 47: 1724-1737.

We examined the old, but untested hypothesis that territory size limits the maximum population density of salmonids in streams. Growth and mortality trajectories of salmonid cohorts from eight experimental studies were compared to the maximum-density regression, the inverse of the territory-size regression. In shallow habitats, such as riffles and raceways, the cohort trajectories followed the maximum density regression quite closely and were consistent with the territory-size hypothesis. Our results suggest that the territory-size regression has practical value for predicting the maximum densities of stream-dwelling salmonids in shallow habitats and the occurrence of density-dependent population responses.

Codes: experi enclos habitat microhab quant popdyn

Grant, J. W. A., S. O. Steingrimsson, E. R. Keeley, and R. A. Cunjak. 1998. Implications of territory size for the measurement and prediction of salmonid abundance in streams. Canadian Journal of Fisheries and Aquatic Sciences 55: 181-190.

Information about territory size is useful for both the measurement and prediction of salmonid abundance. Percent habitat saturation (PHS), the percentage of the stream area occupied by the territories of salmonid fishes, is a better measure of abundance than population density because the former integrates the effects of (a) several age-classes or species in a stream, and (b) variation in growth rate or sampling date. "Effective density" or "effective PHS," calculated by weighting crude density (no. times m super(-2)) or PHS by the number of organisms in the sampling unit, more accurately reflects density from the organism's point of view than does crude density or PHS. Effective density and PHS of Atlantic salmon (Salmo salar) in Catamaran Brook, New Brunswick, increased by 0.4 fish per m super(2) and 4%, respectively, for each order of magnitude decrease in the area of the sampling unit. Literature data suggested that territory size is inversely related to food abundance and can be used to predict changes in salmonid abundance that accompany changes in food abundance. The allometry of territory size was a better predictor of the decline in density of a cohort of Atlantic salmon in Catamaran Brook than the allometry of metabolic requirements.

Codes: habitat quant popdyn noenv temporal

Greenberg, L. A., E. Bergman, and A. G. Eklov. 1997. Effects of predation and intraspecific interactions on habitat use and foraging by brown trout in artificial streams. Ecology of Freshwater Fish 6: 16-26.

We studied habitat use, foraging rates and behavior of 10 cm and 12 cm long brown trout, Salmo trutta, at two densities, 1.5 and 3.0 fish/m super(2), in artificial streams that contained either the amphipod, Gammarus pulex, alone or G. pulex together with the piscivore, northern pike, Esox lucius. Gammarus were stocked in and largely restricted to the pools at a density of 128 Gammarus/m super(2)/pool. Large trout (12 cm) used pools more and riffles less when small trout (10 cm) were present than when small trout were absent. Small trout consumed fewer Gammarus when together with large trout than when alone, but showed no difference in habitat use in the presence and absence of large trout. Habitat use and number of Gammarus consumed per trout were not affected by trout density for either size-class when alone. For both size-classes of trout, use of pools and foraging rates were higher in the absence than in the presence of pike, and pike primarily resided in the pools. The number of aggressive interactions by both size-classes of trout decreased when pike was present. Our results indicate that for habitats that differ in food resources and predation risk, size structure may affect habitat use and foraging by brown trout.

Codes: enclos experi reach quant sppinter trophic

Greenberg, L. A., and J. Dahl. 1998. Effect of habitat type on growth and diet of brown trout, Salmo trutta L., in stream enclosures. Fisheries Management and Ecology [Fish. Manage. Ecol.] 5: 331-348.

The effect of habitat on the growth and diet of brown trout, Salmo trutta L., stocked at the same densities in nine stream enclosures, comprising three habitat types of different quality, were tested. The habitats, which were created based on microhabitat preference data, were a shallow water habitat lacking cobbles (habitat 1), a deeper, mixed cobble-bottomed (128-384 mm diameter) habitat (habitat 2) and a large cobble-bottomed (256-384 mm) habitat of intermediate depth (habitat 3). Brown trout were found to have greater increases in total biomass in habitats 2 and 3 than in habitat 1. The pattern for length did not follow that of biomass as trout had greater increases in total length in habitat 2 than in the other two habitats. Biomass of food in trout diets reflected habitat-specific fish biomass changes, with a greater total biomass of prey as well a greater biomass of the leech, Erpobdella, in habitats 2 and 3 than in habitat 1. There were no habitat-specific differences in the biomass of benthic or drifting invertebrates in the enclosures, with the exception of a tendency for an effect of habitat on the biomass of Erpobdella. Although there may have been habitat-specific differences in food resources that were not detected, it is believed that the higher biomass growth in habitats 2 and 3 may have reflected differences in cover afforded by the deeper water and coarser substrates and/or improved foraging opportunities facilitated by the larger volumes of water in the deeper habitats in which the trout could search for prey.

Codes: enclos experi habitat quant trophic

Gries, G., K. G. Whalen, F. Juanes, and D. L. Parrish. 1997. Nocturnal activity of juvenile Atlantic salmon (Salmo salar) in late summer: Evidence of diel activity partitioning. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 54: 1408-1413.

Paired day-night underwater counts of juvenile Atlantic salmon (Salmo salar) were completed on tributaries of the West River, Vermont, USA, between 28 August and 10 September 1995. At water temperatures ranging from 13 to 23 degree C, the relative count of juvenile salmon was greater at night. Nocturnal counts differed for young-of-the-year and post-young-of-the-year (PYOY) salmon, with PYOY exhibiting almost exclusively nocturnal activity. Nocturnal activity in late summer may enable salmon to maintain population densities when space and suitable feeding areas may be limited. Nocturnal activity of juvenile salmon should be considered in studies of habitat use, competition, time budgets, and associated bioenergetic processes.

Codes: experi quant habitat noenv

Griffith, J. S., and R. W. Smith. 1995. Failure of submersed macrophytes to provide cover for rainbow trout throughout their first winter in the Henrys Fork of the Snake River, Idaho. North American Journal of Fisheries Management 15: 42-48.

Submersed aquatic plants that are abundant in some stream reaches have a potential to provide winter concealment cover for juvenile salmonids. We monitored an index of macrophyte abundance in a portion of the Henrys Fork of the Snake River during two winters that differed in severity and assessed the densities of age-0 rainbow trout Oncorhynchus mykiss associated with the macrophytes. The macrophyte index averaged 84-87% in November 1989 and 1992, and an average of 10-13 fish/100 m super(2) were concealed there. In 1990, macrophyte cover declined to 59% in January and 46% in every February; fish density declined by about one-third by January and dropped to nearly zero in February. In 1992-1993, the macrophyte index declined to an average of 39% following anchor ice formation in December and to 32% in January. Fish density in December was reduced to about half of the November density and to about 1 fish/100 m super(2) in January. Movement of marked fish in 1989-1990 was predominantly from macrophytes into cobble and boulder cover along the bank. During these 2 years, cover provided by submersed macrophytes in the study area was not adequate to hold age-0 rainbow trout the winter. During winter of 1992-1993 no natural bank habitat was available because of low water flows, and we believe that none of the 1992 cohort of rainbow trout survived in the study area.

Codes: reach quant instream temporal

Guay, J. C., D. Boisclair, D. Rioux, C. Leclerc, M. Lapointe, and P. Legendre. 2000. Development and validation of numerical habitat models for juveniles of Atlantic salmon (Salmo salar). Canadian journal of fisheries and aquatic sciences/Journal canadien des sciences halieutiques et aquatiques. Ottawa ON [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 2065-2075.

The ability of numerical habitat models (NHM) to predict the distribution of juveniles of Atlantic salmon (Salmo salar) in a riverwere evaluated. NHMs comprise a hydrodynamic model (to predict water depth and current speed for any given flow) and a biological model (to predict habitat quality for fish using water depth, current speed, and substrate composition). NHMs were implemented with a biological model based on 1) preference curves defined by the ratio of the use to the availability of physical conditions and 2) a multivariate logistic regression that distinguished between the physical conditions used and avoided by fish. Preference curves provided a habitat suitability index (HSI) ranging from 0 to 1, and the logistic regression produced a habitat probabilistic index (HPI) representing the probability of observing a parr under given physical conditions. Pearson's correlation coefficients between HSI and local densities of parr ranged from 0.39 to 0.63 depending on flow. Corresponding values for HPI ranged from 0.81 to 0.98. It was concluded that HPI may be a more powerful biological model than HSI for predicting local variations in fish density, forecasting fish distribution patterns, and performing summer habitat modelling for Atlantic salmon juveniles.

Codes: habitat quant instream ifim warning hem

Hall, J. D., and N. J. Knight. 1981. Natural variation in abundance of salmonid populations in streams and its implications for design of impact studies. EPA-600/S3-81-021. United States Environmental Protection Agency report, Corvallis, OR. July 1981.

Salmonids are the principal fish species of economic importance affected by pollution in the Western United States. Assessment of damage to these fish populations cannot be undertaken without some understanding of the natural variation in abundance within and between populations. An extensive literature review relating to stock size and production of salmonid populations in streams was carried out to bring together data on the magnitude of natural variation in population size and to relate this variability to environmental conditions whenever possible. Temporal and spatial variation may be as high as several orders of magnitude, and are sufficient to mask significant perturbations caused by nonpoint source (NPS) pollutants. Environmental variables most closely associated with spatial variation are those relating to the quality of salmonid habitat, particularly physical characteristics such as cover. Streamflow and food abundance have been associated with both temporal and spatial variation. Considerable emphasis should be placed upon systems of rating habitat quality in attempts to minimize the effects of natural variation when evaluating the impact of NPS pollutants. As a means of more clearly separating natural variation from damage caused by NPS pollutants, more emphasis should be placed upon the study of basic processes in stream ecosystems and more extensive use should be made of paired comparisons in the design of impact studies. (Moore-SRC).

Codes: review multi quant reach temporal instream

Ham, K., and T. Pearsons. 2000. Can reduced salmonid population abundance be detected in time to limit management impacts? CJFAS 57: 17-24.

Eight populations of native salmonids (Oncorhynchus mykiss, Oncorhynchus tsawytscha, Salvelinus confluentus, Oncorhynchus clarki Prosopium williamsoni) were evaluated to determine if rapid, sensitive detection of a reduction in abundance is possible in the Yakima River basin, Washington, where a large-scale test of hatchery supplementation is being conducted. Prospective power to detect impacts to abundance was estimated from 3-16 annual baseline surveys conducted by electrofishing, trapping, or snorkeling. High interannual variation in abundance estimates (CV = 26-94%) prevented detection of small impacts for most taxa. For three taxa, models of environmental and biological influences accounted for between 42 and 49% of temporal variation, increasing our ability to detect impacts of other influences. Detectable impacts for a t test with alpha = 0.1 and beta = 0.1 were >18% for all eight taxa and >54% for four ofeight taxa. It is suggested that population abundance monitoring may not provide feedback sufficiently sensitive or rapid enough to implement corrective actions that prevent impacts from causing harm or exceeding an acceptable level, especially for rare or highly valued taxa with small acceptable impacts.

Codes: multi reach quant risk modeling warning

Hanson, D. L., and T. F. Waters. 1974. Recovery of standing crop and production rate of a brook trout population in a flood-damaged stream. Transactions of the American Fisheries Society 103: 431-439.

The brook trout (Salvelinus fontinalis Mitchill) population in Valley Creek, Minnesota, recovered from heavy flood damage in 1965-66 in terms of standing crop, growth, and production rates over a period of 4 to 5 years. Standing crops of brook trout increased numerically by 20-fold from a low of 498/ha in 1966 to 10,882/ha in 1969, and in biomass by 6-fold from 25 kg/ha in 1966 to a maximum of 148 kg/ha in 1970. Growth rate early in the recovery period was high due to the low density of trout but decreased in successive years as fish density increased. Annual production was about 50 kg/ha during the flood years but increased during the recovery years to a maximum of 167 kg/ha in 1969. Cohort production for the 1965 year class, the one most seriously affected by the floods, was about 15 kg/ha, whereas cohort production for the 1968 year class, the last one that could be completely followed in this study, was about 190 kg/ha. After the floods, rainbow trout (Salmo gairdneri Richardson) immigrated into the study section from downstream; although variable in year class strength, the rainbow contributed substantially to total salmonid standing crop and annual production in some years. It has apparently become permanently established, even after total recovery of the brook trout population.

Codes: experi reach quant popdyn sppinter migrat hydro temporal

Hartman, G. F., and T. G. Brown. 1987. Use of small, temporary, floodplain tributaries by juvenile salmonids in a west coast rain-forest drainage basin, Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 44: 262-270.

Seasonal movement of trout (Salmo clarki and S. gairdneri) into and out of three tributaries which drain areas ranging from 15 to 100 ha within the lower Carnation Creek catchment basin were monitored periodically from 1972 to 1985. The number of trout entering the three tributaries relative to total trout was as high as the number of coho salmon (Oncorhynchus kisutch) entering these tributaries relative to total coho. The percentage of the salmonid population represented by trout was highest in the two largest tributaries and lowest in the smallest. Trout were most clearly associated with nonvegetated sand and gravel bottom portions of the three tributaries. Coho were associated with this habitat too, but they also frequented portions of the tributaries that were vegetated and had a mud substrate. The paper considers some of the implications of use of small drainages by trout to habitat managers.

Codes: quant reach offchann migrat substrate temporal

Hartman, G. F., J. C. Scrivener, and M. J. Miles. 1996. Impacts of logging in Carnation Creek, a high-energy coastal stream in British Columbia, and their implication for restoring fish habitat. Canadian Journal of Fisheries and Aquatic Sciences 53: 237-251.

The land form, surficial geology, and hydrometeorology of the west coast of British Columbia cause streams in the region to be highly variable in flow and vulnerable to land-use disturbance. Carnation Creek, a small drainage in this region, was studied intensively for >20 yr to examine the impacts of forest harvesting. Landslides and debris torrents modified steep slope tributaries and the mainstem of the creek. Bank erosion also altered the stream channel on the alluvial flood plain. These effects were additive in the system and reduced the quality of spawning and rearing habitat for juvenile salmonids. In streams like Carnation Creek, it is necessary to restore some stability to the hill slopes and gullies before attempting fish habitat improvements in the main channel. Salmonid production was limited by combinations of processes and conditions that were different for each species and life-history stage. Knowledge of the processes that limit fish production must be applied in habitat improvement work or the projects risk failure. Programs intended to restore natural function to systems or to improve habitat for fish must be planned, evaluated, and reported methodically if they are to succeed and provide information of use to future programs.

Codes: reach quant ripar lulc temporal warning

Hartzler, J. R. 1983. The effects of half-log covers on angler harvest and standing crop of brown trout in McMichales Creek, Pennsylvania. North American Journal of Fisheries Management 3: 228-238.

Approximately 40 m super(2) of supplemental shelter provided by 68 half-log cover devices were added to 700 m (0.52 hectare) of McMichaels Creek, a relatively infertile stream in eastern Pennsylvania. A control area of similar size was left undeveloped. Angling data and yearly electrofishing inventories were used to measure changes in the standing crops of brown trout (Salmo trutta)) greater than or equal to 200 mm (catchable-size) and 100-199 mm long (subcatchable). Anglers creeled 10% more trout in treated sections after cover installation, wherease the brown trout harvest declined by 11% in the untreated sections. Numbers and biomass of brown trout greater than or equal to 200 mm in control sections declined in postdevelopment years. Standing crops of smaller trout increased significantly in both cover and control sections, with the greatest changes occurring in control areas. The poor response of "catchable-size" brown trout to cover enhancement in McMichaels Creek was attributed to the presence of abundant natural cover. Environmental factors other than shelter apparently determined the density of subcatchable trout.

Codes: experi reach quant instream lwd

Harvey, B. C. 1986. Effects of suction gold dredging on fish and invertebrates in two California streams. North American Journal of Fisheries Management 6: 401-409.

I examined the impact of small suction dredges (hose diameter, <16 cm) on fish and invertebrates in two California streams (North Fork of the American River and Butte Creek) in a 2-year study. I studied both the effect of one dredge (1980) and the effects of an average of six dredges in a 2-km section of stream (1981). Ten replicate Surber samples per station were taken monthly to compare macroinvertebrate abundances at control and dredged stations before, during and after dredging in both years. Dredging significantly affected some insect taxa when substrate was altered. A recolonization experiment showed that numerical recovery of insects at dredged sites was rapid. Mask-and-snorkel censuses and observations of tagged fish indicated that major changes in available habitat caused local decreases in fish density. Dredging affected riffle sculpins (Cottus gulosus) more severely than rainbow trout (Salmo gairdneri), probably because of differences in microhabitat requirements. Local turbidity increases below active dredging probably did not affect invertebrates and fish.

Codes: multi experi habitat quant substrate

Harvey, B. C. 1998. Influence of large woody debris on retention, immigration, and growth of coastal cutthroat trout (Oncorhynchus clarki clarki) in stream pools. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 55: 1902-1908.

Over 4 months and about 1 year coastal cutthroat trout (Oncorhynchus clarki clarki) greater than or equal to age-1 in Little Jones Ceek, California, remained at similar rates in pools with and without large woody debris. This result was based on attempts in July and November 1995 to collect and tag all fish in 22 pools and three collections of fish from the same pools in November 1995, May 1996, and August 1996. Retention of fish appeared to be greater in pools with large woody debris in May 1996. The presence of large woody debris in pools did not influence immigration or growth of cutthroat trout. Both immigration and growth increased downstream over the 3850-m study reach. Low retention and substantial immigration of cutthroat trout into experimental pools indicate that movement is important in the dynamics of this population. First- and second-order channels appear to be important sources of fish for the third-order study reach, while the study reach may export significant numbers of fish to downstream reaches accessible to anadromous fish.

Codes: experi habitat reach quant migrat lwd

Harvey, B. C., and R. J. Nakamoto. 1996. Effects of steelhead density on growth of coho salmon in a small coastal California stream. Transactions of the American Fisheries Society 125: 237-243.

Weight change in age-0 coho salmon Oncorhynchus kisutch at about natural density was negatively related to the density of juvenile steelhead (anadromous rainbow trout O. mykiss) in a 6-week experiment conducted in July-August 1993 in the north and south forks of Caspar Creek, California. The experiment used 12 enclosed stream sections, each containing a pool and a portion of upstream riffle, with two replicates of three steelhead densities-zero, natural density (1x), and twice the natural density (2x)-on both the north and south forks. The natural density of coho salmon was about one-sixth the density of steelhead. Coho salmon survival was high (87% overall) and not related to treatments. In the north fork, coho salmon weight change was positive in zero density steelhead treatments, zero in 1x treatments, and negative in 2x treatments. Coho salmon weight change in the south fork was less favorable than in the north fork but was also negatively related to the density of steelhead. These results indicate that under some conditions resource partitioning by salmonid species does not eliminate negative interspecific interactions.

Codes: experi enclos reach quant sppinter popdyn

Harvey, B. C., and R. J. Nakamoto. 1997. Habitat-dependent interactions between two size-classes of juvenile steelhead in a small stream. Canadian Journal of Fisheries and Aquatic Sciences 54: 27-31.

The presence of small steelhead (Oncorhynchus mykiss; averaging 55 mm fork length) influenced the growth of larger juvenile steelhead (90 mm fork length) during a 6-week experiment conducted in North Fork Caspar Creek, California, in summer 1994. In fenced replicate deep stream sections in this small stream, growth of the larger steelhead was greater in treatments in which small steelhead constituted half of the total biomass of fish than in treatments with an equal biomass comprised entirely of larger fish. In shallow habitats, growth of larger fish was lower in the presence of small fish. The growth of small fish was unaffected by the presence of larger juveniles and also was independent of habitat. Survival of both size-classes was high (70-90%) and unrelated to habitat or the presence of the other size-class. The advantage of large body size in intraspecific interactions among steelhead does not exist in all types of habitat, and interactions between the two size-classes may contribute to lower abundance of large juveniles in streams where aggradation reduces water depth.

Codes: experi enclos reach quant sppinter popdyn instream

Haury, J., and J. L. Bagliniere. 1996. Macrophytes as structuring component for fish habitat in a salmonid river. A study of fish microrepartition in a macrophyte site in the River Scorff (southern Brittany). Cybium. Paris 20: 111-127.

A review of the ecological functions of the macrophytes in the Armorican rivers is presented along with unpublished data, within a multi-compartment framework. Macrophytes have a fair cover (>80% of the river bed) in salmonid rivers of the Armorican Massif. At the river network scale, macrophytes show a longitudinal zonation, and they can be used as physical bio-indicators. At a local scale, macrophytes present patches into the river bed, belts on, or close to, the banks, and a multi-layer composition involving various eco-morphological types. The seasonal variability of macrophyte cover is important, from 9 to 95% of river bed. In summer, the mean biomass of macrophytes is about 160g of dry matter per m2. The main hydrodynamical effects of macrophytes are modifications of current velocity and trapping of fine particles. General interactions with fish are presented comparing plant and fish cycles, and showed the prominence of indirect effects on fish community. A study of fish microdistribution within a heavily covered stretch of the River Scorff is presented. In late June and close September, the vegetation maps showed the spatial and seasonal variability of macrophytes. In June, one of the seven physically homogeneous habitats had a 100% cover by Ranunculus penicillatus and mainly had scarce Planer's lampreys (Lampreta planeri). Young salmons (Salmo salar) avoided macrophytes and other shelters: they standed in open current areas. Trouts (Salmo trutta), specially the oldest ones, were located closer to shelters due either to macrophytes or shaded banks. Eels (Anguilla anguilla) and pikes (Esox lucius) used the same biotopes, with slow waters and bank shelters. Lampreys (Lampetra planeri) stayed in plant shelters, specially close to banks where fine sediments were deposited. Minnows (Phoxinus phoxinus) were caught in open water, not far from shelters. Stone-loaches (Nemacheilus barbatula) and bullheads (Cottus gobio) were found in coarse bed substratum. This study concluded to negative effects of large macrophyte cover upon the distribution and density in most fish species.

Codes: multi qual microhab instream

Haury, J., J. L. Bagliniere, A. I. Cassou, and G. Maisse. 1995. Analysis of spatial and temporal organization in a salmonid brook in relation to physical factors and macrophytic vegetation. HYDROBIOLOGIA

Codes: reach quant? instream

Hawkins, C. P., M. L. Murphy, N. H. Anderson, and M. A. Wilzbach. 1983. Density of fish and salamanders in relation to riparian canopy and physical habitat in streams of the northwestern United States. Canadian Journal of Fisheries and Aquatic Sciences 40: 1173-1185.

Relationships between density of fish and salamanders, riparian canopy, and physical habitat were investigated by studying 10 pairs of streams. Among vertebrate taxa, salmonids and sculpins were more abundant in streams without riparian shading than in shaded streams. Abundance of salamanders was not affected by canopy type. Densities of both salamanders and sculpins were correlated with substrate composition, whereas salmonid abundance was not or only weakly so. Salamanders were found only at high-gradient sites with coarse substrates, and sculpins were most abundant at lower-gradient sites with finer-sized sediments. An interaction was observed between the influence of canopy and that of physical setting on density of both invertebrate prey and total vertebrates.

Codes: multi reach quant ripar substrate instream

Hayes, J. W. 1995. Spatial and temporal variation in the relative density and size of juvenile brown trout in the Kakanui River, North Otago, New Zealand. New Zealand Journal of Marine and Freshwater Research 29: 393-407.

Spatial and temporal variation in relative density of 0+ and 1+ brown trout (Salmo trutta) was examined over three summers in the Kakanui River, North Otago, New Zealand. Both 0+ and 1+ trout were distributed throughout the river. Spatial variation in relative density was much higher than annual variation. Within years, relative density of 0+ brown trout varied by 5 to 92 times between sites (mean coefficient of variation, CV = 1.08) and of 1+ trout by 18 to 84 times between sites (CV = 1.13). Mean relative density of 0+ brown trout varied by 1.5 to 2.0 times between years (CV = 0.35) and of 1+ trout by 3.6 to 23.2 times between years (CV = 0.96). The pattern of 0+ trout spatial distribution was not closely related to the distribution of redds (which also were distributed throughout the river) and not related to the distribution of benthic invertebrate food. By their second summer, most trout occupied the middle and lower reaches of the river. Mean length of both 0+ and 1+ trout increased with distance downstream. Floods greater than 290 m super(3) s super(-1), and with a return period of 4 years, during the late incubation and early fry stages (August-November) were associated with impaired recruitment, yet a large flood (816 m super(3) s super(-1)) in March 1994 had no apparent effect on the survival of 0+ trout 80-100 mm in length.

Codes: reach quant hydro trophic temporal noenv

Hearn, W. E., and B. E. Kynard. 1986. Habitat utilization and behavioral interaction of juvenile Atlantic salmon (Salmo salar) and rainbow trout (S. gairdneri) in tributaries of the White River of Vermont. Canadian Journal of Fisheries and Aquatic Sciences 43: 1988-1998.

Competition for space between stocked juvenile Atlantic salmon, Salmo salar, and wild juvenile rainbow trout, S. gairdneri, was examined in stream channel experiments, a field experiment, and in field habitat surveys. In stream channels providing riffle and pool habitats, species differed in their distribution both as underyearlings (0+) and as yearlings (1+). Yearling salmon occurred more often in stream channel riffles during trials with 1+ rainbow trout than during trials testing only salmon. In a field experiment conducted to determine if the stocking of 0+ Atlantic salmon causes the displacement of resident 0+ rainbow trout, salmon fry were stocked at a density of 85 per 100 m super(2). The authors found no evidence of competition between cohorts of underyearlings; however, the niche shift by 1+ salmon in the stream channels suggested that, at times, juveniles of these species will compete for space.

Codes: experi reach habitat quant sppinter

Heggenes, J. 1988. Effect of experimentally increased intraspecific competition on sedentary adult brown trout (Salmo trutta) movement and stream habitat choice. Canadian Journal of Fisheries and Aquatic Sciences 45: 1163-1172.

Movements and habitat choice of 19 brown trout (Salmo trutta) resident in a stream was monitored during one season, while in the next season the population was increased by introducing 130 wild brown trout captured further downstream. No differences in the movement patterns of resident trout at the two population densities, or of residents compared with nonresidents, were found. Median movement distance was 0 m. Sixty-six percent of the movements were less than plus or minus 50 m, 11% were between 50 and 100 m, and 23% were greater than plus or minus 100 m. Introduced nonresident trout occupied habitats different from those occupied by residents. Nonresidents were more often observed in shallower areas with less cover and finer substrate, i.e. less preferred habitats.

Codes: habitat migrat instream

Heggenes, J. 1988. Physical Habitat Selection by Brown Trout (Salmo trutta) in Riverine Systems. Nordic Journal of Freshwater Research 64: 74-90.

Knowledge about habitat requirements of brown trout (Salmo trutta) is important for stream management and impact assessment. The method of observation may influence the habitat suitability results obtained. The best approach may be to adopt a combination of direct underwater observation and electrofishing, if a variety of habitat conditions are studied. A distinction should be made between physical habitat variables affecting in situ habitat choice and habitat variables affecting carrying capacity, such as, boundary conditions, because their spatio-temporal dimensions are different. Water depth, water velocity, streambed substrate and cover seem to be the most important physical stream characteristics influencing in situ habitat choice by brown trout. Preferred habitat is positively correlated with fish size. Smaller brown trout occupy shallow riffle areas with cobble substrate, while the larger fish prefer deeper stream areas with cobble/boulder substrate and abundant cover. All sizes of fish seek out low water velocity micro-niches to minimize energy expenditure. Different studies emphasize the importance of different habitat variables. This is probably a reflection of the diverse factors modifying habitat selection. Total available habitat should be quantified in all habitat analysis studies, because availability can modify habitat choice strongly. Different habitat characteristics may be the limiting factors in different streams and true habitat preferences cannot therefore be constructed from habitat use data alone. Furthermore, habitat selection may be modified by biological factors such as fish population density and composition, food supply and presence of other species. In addition greater attention should be given to the possible interactions between physical habitat variables. (Author 's abstract).

Codes: review habitat microhab substrate instream

Heggenes, J. 1996. Habitat selection by brown trout (Salmo trutta) and young Atlantic salmon (S. salar) in streams: static and dynamic hydraulic modelling. Regulated Rivers Research & Management 12: 155-169.

Brown trout (Salmo trutta) and young Atlantic salmon (S. salar) in streams are selective in their habitat use, which is partially determined by hydro-physical conditions. Habitat selection may be quantified in models and combined with hydraulic models to evaluate instream habitat suitability. Fish occupancy of habitat depends on the fish species and size. Brown trout prefer deep stream areas with moderate to low water velocities and rocky substrates, whereas young Atlantic salmon chose more fast flowing and often shallower areas. Habitat selection has been quantified in static selection models which should be based on measures of habitat usage and availability (preferences) and combined with data on hydro-physical conditions to build predictive habitat models. Such models assess habitat availability and capacity rather than discharge-biomass relationships. Limitations of static models in fish habitat studies are (1) the relevant hydrophysical variables are not included, (2) the interaction terms are difficult to quantify and not incorporated, (3) the hydraulic models may not operate on a spatial scale that is relevant to fish, (4) the models include spatial but only to a limited extent temporal heterogeneity in habitat conditions and (5) biotic factors are not included. Streams may be extremely heterogeneous ecosystems, both spatially and temporally, which may influence habitat selection and modelling. In response to varying habitat availabilities (stream size and structure, water flows) habitat selection in brown trout and young Atlantic salmon is dynamic and relatively flexible. Furthermore, changes in temperature may result in seasonal and daily niche shifts. Therefore unless the dynamic aspects of habitat selection are incorporated into the habitat models, long-term predictive power in habitat-hydraulic modelling is unlikely. However, habitat-hydraulic modelling is useful tool in a 'no net loss of habitat' management strategy regardless of these shortcomings.

Codes: review modeling microhab habitat hydro ifim warning hem

Heggenes, J., J. L. Bagliniere, and R. A. Cunjak. 1999. Spatial niche variability for young Atlantic salmon (Salmo salar) and brown trout (S. trutta) in heterogeneous streams. Ecology of Freshwater Fish [Ecol. Freshwat. Fish] 8: 1-21.

Habitat is important in determining stream carrying capacity and population density in young Atlantic salmon and brown trout. We review stream habitat selection studies and relate results to variable and interacting abiotic and biotic factors. The importance of spatial and temporal scales are often overlooked. Different physical variables may influence fish position choice at different spatial scales. Temporally variable water flows and temperatures are pervasive environmental factors in streams that affect behavior and habitat selection. The more frequently measured abiotic variables are water depth, water velocity (or stream gradient), substrate particle size, and cover. Summer daytime, feeding habitats of Atlantic salmon are size structured. Larger parr (>7 cm) have a wider spatial niche than small parr. Selected snout water velocities are consistently low (3-25 cm times s super(-1)). Mean (or surface) water velocities are in the preferred range of 30-50 cm times s super(-1), and usually in combination with coarse substratum (16-256 mm). However, salmon parr demonstrate flexibility with respect to preferred water velocity, depending on fish size, intra- and interspecific competition, and predation risk. Water depth is less important, except in small streams. Summer daytime, feeding habitat of brown trout is also characterized by a narrow selection of low snout water velocities. Habitat use is size-structured, which appears to be mainly a result of intraspecific competition. Water depth is considered the most important habitat variable for brown trout. Spatial niche overlap is considerable where the two species are sympatric. Habitat use by salmon is restricted through interspecific competition with the more aggressive brown trout (interactive segregation). However, subtle innate differences in behavior at an early stage also indicate selective segregation. Seasonal changes in habitat use related to water temperatures occur in both species. While active at night, the fish move to more exposed holding positions primarily on but also above the substrate. Diurnal changes in habitat use take place also in summer.

Codes: review microhab habitat qual sppinter wtemp hydro

Heggenes, J., T. G. Northcote, and A. Peter. 1991. Spatial stability of cutthroat trout (Oncorhynchus clarki) in a small, coastal stream. Canadian Journal of Fisheries and Aquatic Sciences 48: 757-762.

Spatial stability and local movement of a cutthroat trout (Oncorhynchus clarki) population were studied from winter to late summer in a small, coastal stream. The majority of the population was static and resided within a home range < 22 m super(2), while a small fraction of the fish apparently was more mobile. Local movement was very restricted; 32.4% of the individually marked cutthroat were recaptured within 1 m of their original capture and marking site, and 48% remained within 3 m of that site. Only 17.9% of the fish moved more than 50 m. This behaviour was stable during winter, spring, and summer and may be of adaptive significance. Fish occupying pool areas moved considerably less than fish occupying shallow habitats, indicating that pool dwellers were dominant fish.

Codes: reach migrat qual instream

Heggenes, J., and S. J. Saltveit. 1990. Seasonal and spatial microhabitat selection and segregation in young Atlantic salmon, Salmo salar L., and brown trout, Salmo trutta L., in a Norwegian river. Journal of Fish Biology 36: 707-720.

Seasonal microhabitat selection by sympatric young Atlantic salmon and brown trout was studied by diving. Both species, especially Atlantic salmon, showed seasonal variation with respect to surface and mean water velocities and depth. This variation is partly attributed to varying water flows and water temperatures. In winter the fish sought shelter in the substratum. A spatial variation in habitat use along the river due to different habitat availabilities was observed. Both species occupied habitats within the ranges of the microhabitat variables, rather than selecting narrow optima. It is hypothesized that the genetic basis allows a certain range to the behavioural response. Microhabitat segregation between the two species was pronounced, with brown trout inhabiting the more slow-flowing and partly more shallow stream areas. Atlantic salmon tolerated a wider range of water velocities and depths. Habitat suitability curves were produced from both species. It is suggested that habitat suitability curves that are based on observations of fish occupancy of habitat at median or base flow may not be suitable in habitat simulation models, where available habitat is projected at substantially greater water flows.

Codes: microhab qual sppinter instream ifim warning hem

Heifetz, J., M. L. Murphy, and K. V. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaskan streams. North American Journal of Fisheries Management 6: 52-58.

Effects of logging on preferred winter habitats of juvenile salmonids in southeastern Alaskan streams were assessed by comparing the area of preferred winter habitat in 54 reaches of 18 streams. Three types of streams were sampled at each of six locations: a stream in a mature, undisturbed forest; a stream in a clear-cut area but logged on at least one bank; and a stream in a clear-cut area with strips of forest (buffer strips) along the stream bank. To identify preferred winter habitats, we classified stream areas in 12 of 18 streams into discrete habitat types and compared the density of salmonids within these habitat types with average density of the entire reach. Most wintering coho salmon (Oncorhynchus kisutch), Dolly Varden (Salvelinus malma), and steelhead (Salmo gairdneri) occupied deep pools with cover (i.e., upturned tree roots, accumulations of logs, and cobble substrate). Riffles, glides, and pools without cover were not used. Seventy-three percent of all pools were formed by large organic debris. Reaches in clear-cut areas without buffer strips had significantly less area of pool habitat than old-growth reaches. Buffer strips protected winter habitat of juvenile salmonids by maintaining pool area and cover within pools. In some cases blowdown from buffer strips added large organic debris to the stream and increased the cover within pools.

Codes: multi habitat reach qual? instream lwd substrate ripar

Herger, L. G., W. A. Hubert, and M. K. Young. 1996. Comparison of habitat composition and cutthroat trout abundance at two flows in small mountain streams. North American Journal of Fisheries Management 16: 294-301.

We assessed habitat features measured in the recently developed basinwide habitat inventory for their relations to abundance of native cutthroat trout Oncorhynchus clarki in small streams of the Rocky Mountains. We also evaluated the manner in which habitat and fish abundance changed as streamflow declined during the summer sampling season. Our observations corroborated the assumption that the basinwide habitat inventory is a valid technique for identifying channel unit types with differing levels of use by cutthroat trout. We found higher biomass of cutthroat trout in pools than in glides or riffles. Plunge pools and higher biomass than dammed pools. Biomass was greater in low-gradient riffles than in rapids, and no fish were found in cascades. We observed an increase in the abundance of channel unit types, changes in the physical dimensions of channel unit types, and a decrease in overall stream length with declines in flow. We concluded that the basinwide habitat inventory does identify habitat features affecting the abundance of cutthroat trout, but variation in flow during summer changes the relative abundance and physical features of habitat units. Comparisons of basinwide inventories among years within a specific watershed may be affected by differences in discharge, so inventories should be conducted at similar discharges to enable meaningful assessment of possible changes in habitat.

Codes: multi habitat quant instream hydro

Hesthagen, T., J. Heggenes, B. M. Larsen, H. M. Berger, and T. Forseth. 1999. Effects of water chemistry and habitat on the density of young brown trout Salmo trutta in acidic streams. Water, Air, & Soil Pollution [Water, Air, Soil Pollut.] 112: 85-106.

We examined the relationship between young brown trout (Salmo trutta) density in lake tributaries, and water chemistry and habitat variables. The study was carried out during the autumn in three acidic, softwater river systems in western and southwestern Norway; Gaular and Vikedal (1987-1993) and Bjerkreim (1988-1993). The streams had mean calcium concentrations of 0.35 mg L super(-1) (Gaular), 0.52 mg L super(-1) (Vikedal) and 0.84 mg L super(-1) (Bjerkreim). The concentration of inorganic Al was generally low, with mean values of 8.40 (Gaular), 22.22 (Vikedal) and 43.36 mu g L super(-1) (Bjerkreim). In multiple regressions that involved different water chemistry variables, brown trout density correlated best with calcium concentration and with a combination of calcium and pH; the Ca super(2+):H super(+) ratio. In Vikedal and Gaular, calcium explained 51 and 57%, respectively, of the variability in brown trout densities. Althoug alkalinity exhibited the best correlation with brown trout density in Bjerkreim (r super(2)=0.33), it was similar to that of the model that included all major ions plus pH. The Ca super(2+):H super(+) ratio had a larger effect for variability in brown trout density in Gaular (r super(2)=0.66) than calcium alone. In Vikedal and Bjerkreim, the Ca super(2+):H super(+) ratio also correlated with brown trout density, but considerably less than in Gaular. The predictive power of habitat variables was much lower than that of water chemistry; the single most important factors were altitude in Gaular (r super(2)=0.22), mean water temperature in Vikedal (r super(2)=0.11) and depth SD (index of heterogeneity) in Bjerkreim (r super(2)=0.07). Models that included both habitat and water chemistry variables showed that the density of young brown trout was predicted primarily by calcium concentrations in Gaular (r super(2)=0.75) and Vikedal (r super(2)=0.54), as opposed to pH in Bjerkreim (r super(2)=0.25). Habitat had low effect in all three river systems (r super(2)=0.01-0.04). The final model explained 86, 68 and 32%, respectively, of the variability in brown trout density in the three catchments. Thus, water chemistry variables seem to be factors that limit the density of young brown trout in acidic softwater streams.

Codes: multi reach quant watqual instream warning wtemp

Hetrick, N. J., M. A. Brusven, T. C. Bjornn, R. M. Keith, and W. R. Meehan. 1998. Effects of canopy removal on invertebrates and diet of juvenile coho salmon in a small stream in southeast Alaska. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 127: 876-888.

We assessed changes in availability and consumption of invertebrates by juvenile coho salmon Oncorhynchus kisutch in a small stream in southeast Alaska where patches of dense second-growth riparian vegetation bordering the stream had been removed. Benthic invertebrate populations were assessed during summer 1988 and 1989 with a Hess sampler. Aerial invertebrates were sampled during summer 1989 with wire-mesh sticky traps hung just above the water surface and with floating clear-plastic pan traps. Invertebrate drift was assessed during summer 1989 with nets placed at the downstream end of closed- and open-canopy stream sections. Diets of age-0 and age-1 coho salmon were sampled by flushing stomach contents of fish collected from closed- and open-canopy stream sections. Abundance and biomass of benthic invertebrates were larger in open- than in closed-canopy stream sections and were primarily dipterans, ephemeropterans, and plecopterans. More insects were caught on sticky traps in open than in closed sections on two of four dates sampled, and composition of the catch was primarily dipterans (74% in both closed- and open-canopy sections).

Codes: experi reach qual ripar trophic

Hetrick, N. J., M. A. Brusven, W. R. Meehan, and T. C. Bjornn. 1998. Changes in Solar Input, Water Temperature, Periphyton Accumulation, and Allochthonous Input and Storage after Canopy Removal along Two Small Salmon Streams in Southeast Alaska. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 127: 859-875.

Changes in solar radiation, water temperature, periphyton accumulation, and allochthonous inputs and storage were measured after we removed patches of deciduous, second-growth riparian vegetation bordering two small streams in southeast Alaska that produce coho salmon Oncorhynchus kisutch. Solar radiation and leaf litter input were measured at the water surface at random locations dispersed through six alternating closed- and open-canopy stream sections. Water temperature, periphyton, and stored organic samples were collected near the downstream end of each section. Solar radiation intensity was measured with digital daylight integrators and pyronometers, periphyton biomass and chlorophyll a were measured on red clay tile substrates, allochthonous input was measured with leaf litter baskets, and benthic organic matter was measured with a Hess sampler. Average intensity of solar radiation that reached the water surface of open-canopy sections was significantly higher than in closed-canopy sections of two streams measured during daylight hours in summer 1988 and of one stream measured day and night in summer 1989.

Codes: experi multi nofish ripar wtemp trophic

Hicks, B. J. 1990. The influence of geology and timber harvest on channel morphology and salmonid populations in Oregon Coast Range streams. Dissertation Dissertation, Oregon State University.

Geology influences mainstem channel morphology in streams of about 1500 ha basin area in the Oregon Coast Range. Habitat availability and salmonid populations were surveyed in 3 km of main channel in each of five streams in basalt and five streams in sandstone. Differences in channel morphology were related to channel gradient (measured from topographic maps). Streams in basalt had a mean gradient of 2.5 plus or minus 0.6% (mean plus or minus 95% confidence limits), compared to 1.2 plus or minus 0.5% for streams in sandstone with the same basin area. The streams in sandstone had greater mean frequency of pools (28 pools per kilometer) than the streams in basalt (18 pools per kilometer, Mann-Whitney U test, $p = 0.016$). Mean frequency of glides (17 and 19 glides per kilometer) and riffles (26 and 23 riffles per kilometer) in streams in basalt and sandstone was not different (Mann-Whitney U test, $p > 0.15$). However, riffles were almost twice as long in streams in basalt (14.6 m, geometric mean length) as in sandstone (7.7 m), and this difference in length was significant (Mann-Whitney U test, $p = 0.008$). Salmonid populations in streams in different rock types reflected the relative habitat availability. Streams in basalt were dominated by steelhead (Oncorhynchus mykiss), and cutthroat trout (Oncorhynchus clarki). In contrast, streams in sandstone were dominated by coho salmon (Oncorhynchus kisatch). Age 0 coho salmon, and age 1 and older steelhead, resident rainbow trout, and cutthroat trout occupied pools more than glides or riffles. Age 0 steelhead and trout occupied pools, glides, and riffles about equally, except that pools in sandstone and riffles in basalt were slightly avoided. Mean densities of salmonids in streams in sandstone were greater than those in basalt. Salmonid biomass in basalt and in sandstone, however, was similar because fish of the same species and age class were larger in streams in basalt than in sandstone, and there were also more age 1 and older fish in streams in basalt. Timber harvest did not influence channel morphology significantly, except that the number of pools associated with large woody debris declined with increasing timber harvest. Streamflows in summer were generally much greater in basalt than in sandstone, though differences in rainfall influenced these streamflow differences. Coastal streams generally had higher flows than those further inland, but a stream in basalt had a higher base flow than streams in sandstone with similar summer climates. Timber harvest appeared to influence low flows in streams in sandstone.

Apparent survival of age 0 trout was related to summer low flows in streams in sandstone, and these flows were inversely related to amount of timber harvest. (DBO).

Codes: multi reach quant instream ripar lulc

Hicks, B. J., J. D. Hall, P. A. Bisson, and J. R. Sedell. 1991. Responses of salmonids to habitat changes. Pages 484-518. In The influence of forest and rangeland management on salmonids and their habitat. W. R. Meehan, editors. American Fisheries Society Special Publication 19, Bethesda, MD.

Codes: review multi reach quant lulc instream temporal

Hillman, T. W., J. S. Griffith, and W. S. Platts. 1987. Summer and winter habitat selection by juvenile chinook salmon ina highly sedimented Idaho stream. Transactions of the American Fisheries Society 16: 185-195.

Summer and winter habitat utilized by age-0 spring chinook salmon Oncorhynchus tshawytscha was assessed in the Red River, an Idaho stream heavily embedded with fine sediment. During summer 1985, chinook salmon used habitats with water velocities less than 20 cm/s, depths of 20-80 cm, and close associations with cover (undercut banks). Densities were greater than 60 fish/100 m super(2). As the fish became larger they selected faster, deeper water. Eighty percent of the chinook salmon emigrated from the study sites in October when stream temperatures were 4-8 degree C, apparently because suitable winter habitat was not available.

Codes: habitat quant instream

Holtby, L. B. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on the coho salmon (Oncorhynchus kisutch). CJFAS 45: 502-515.

#cited in Hicks et al. 1991, p.501-2 regarding high survival in floodplains. #

Codes: quant popdyn basin wtemp lulc offchann temporal

Holtby, L. B., and J. C. Scrivener. 1989. Observed and simulated effects of climatic variability, clear-cut logging and fishing on the numbers of chum salmon (Oncorhynchus keta) and coho salmon (O. kisutch) returning to Carnation Creek, British Columbia. Edited by C. D. Levings, L. B. Holtby and M. A. Henderson, 62-81 p.

The population dynamics of coho and chum salmon have been studied at Carnation Creek since 1970 as part of a multi-disciplinary study of the effects of logging on a small salmon stream in a coastal rainforest. The authors have developed models that predict the numbers of chum and coho salmon from correlative relationships between survival and growth at various life stages and (1) climatic, hydrologic and physical variables, (2) indices of those features of the stream habitat that were affected by logging and, (3) exploitation rates in the fishery. The authors suggest that overall variability in the salmon abundance will tend to increase in the wake of land-use activities, particularly when accompanied by high levels of exploitation and adverse environmental conditions.

Codes: modeling reach quant hydro ripar lulc temporal

Horan, D. L., J. L. Kershner, C. P. Hawkins, and T. A. Crowl. 2000. Effects of habitat area and complexity on Colorado River cutthroat trout density in Uinta Mountain streams. Transactions of the American Fisheries Society 129: 1250-1263.

Habitat degradation has reduced the complexity and connectivity of streams on the north slope of the Uinta Mountains in northeastern Utah. These changes have diminished the historical range of Colorado River cutthroat trout Oncorhynchus clarki pleuriticus, isolated the populations of this subspecies, and perhaps increased its risk of extinction. We assessed the effects of fragment area and habitat complexity on Colorado River cutthroat trout density. We studied 88 reaches in 4 isolated stream fragments. At the fragment scale, both the density of adults and habitat complexity increased significantly as fragment size increased. In the smaller fragments, the density of adults was lower while that of juveniles was higher. Habitat differed substantially among fragments. At the reach scale, the density of adults was positively related to elevation, the percentage of undercut banks, and mean substrate particle size and negatively related to residual pool depth and the extent of large woody debris. The density of juveniles was positively related to the extent of large woody debris and negatively related to residual pool depth and stream width. The habitat complexity index was weakly related to adult density at the reach scale. We were not able to distinguish the influence of habitat area or complexity on the density of adults, but a population living in an isolated stream fragment with low habitat complexity probably requires more area to persist than a population of the same size living in a highly complex habitat.

Codes: multi reach segment quant instream lwd substrate

House, R. 1995. Temporal variation in abundance of an isolated population of cutthroat trout in western Oregon, 1981-1991. North American Journal of Fisheries Management 15: 33-41.

The magnitude of variation in an isolated population of wild coastal cutthroat trout Oncorhynchus clarki clarki is described for an 11-year study period during which conditions in a Cascade Mountain drainage in western Oregon were relatively stable. Dead Horse Canyon Creek watershed, which drains 1,376 ha in the upper Molalla River, experienced no storm events or disturbances of riparian habitat that caused major changes in channel configuration. Cutthroat trout populations in Dead Horse Canyon Creek varied from year to year, while habitat conditions remained constant, which thereby complicated any analyses of the independent effects of land management activities on the population. The cutthroat trout population fluctuated substantially fish the least. Because most of the habitat models used to predict changes in trout populations do not incorporate natural variations in populations under similar habitat conditions, measuring the impact of land management activities by short-term studies may result in erroneous conclusions. Based on Dead Horse Canyon Creek monitoring, models that obtain data by separating habitat types and that consider only older age-classes of trout may be the most accurate in predicting changes in population levels.

Codes: reach quant ripar instream temporal warning

House, R. 1996. An evaluation of stream restoration structures in coastal Oregon stream, 1981-1993. North American Journal of Fisheries Management 16: 272-281.

A 1.7-km reach of East Fork Lobster Creek, an Oregon coastal tributary of the Alsea River, was treated with mostly full-spanning, rock-filled gabions in 1981 and boulder structures in 1987. East Fork Lobster Creek (EFLC) supports runs of coho salmon Oncorhynchus kisutch and fall chinook salmon O. tshawytscha winter steelhead O. mykiss, and sea-run and resident cutthroat trout O. clarki. The main objective of treatment was to improve spawning and summer rearing habitat for coho salmon, habitat determined to be lacking during 1980 surveys. Freshets in the winter of 1981-1982 filled all gabion structures with large gravel; the surface area of pool and low-gradient riffle habitat increased but area of high-gradient riffle habitat decrease. From 1985 through 1993, the average number of coho salmon spawners in EFLC increased 2.5 times compared with returns during 1981-1984. In EFLC, treated areas supported significantly more juvenile coho salmon and cutthroat trout and had higher overall salmonid biomass than control areas, whereas age-0 trout (cutthroat trout plus steelhead) and juvenile steelhead showed no increases. For the entire 1.7-km reach receiving treatment, the number of coho salmon juveniles was higher after than before treatment, whereas numbers of steelhead and cutthroat trout fry and juveniles remained constant. Between 1981 and 1992, over 50% of the coho salmon and steelhead spawned on newly deposited, higher-quality gravels associated with 15 gabion structures that fully spanned the bank-full channel width. Quality of gravels impounded by gabions equaled or exceeded the quality of gravels in unmodified areas of the creek. Habitats, primarily pools, created by gabion structures lasted 10 years; however, disintegration of wire mesh tops starting in 1989 caused a slow reduction in pool habitat and gravel riffles at treated sites. All boulder structures remained functional in 1992. Results of this study provide some evidence that interim instream restoration to improve degraded streams and increase salmonid stocks at risk of extinction can be used until long-term watershed restoration strategies have been implemented.

Codes: experi reach instream substrate temporal

House, R. A., and P. L. Boehne. 1985. Evaluation of instream enhancement structures for salmonid spawning and rearing in a coastal Oregon stream. North American Journal of Fisheries Management 5: 283-295.

East Fork Lobster Creek, Oregon is an example of a stream that lost much of its productivity as an anadromous salmonid stream following logging activities, intensive stream cleaning, and flooding. The stream in the study area was almost devoid of instream structures, resulting in a nearly total lack of spawning gravel and rearing habitat. Stream enhancement structures installed in East Fork Lobster Creek were successful and functional after two winters with usual freshets. The structures dramatically increased the diversity of the stream bed, trapped gravel, and created shallow gravel bars and deep, covered pools. Also, the number, size, and quality of the pools increased in areas with structures. Coho salmon (Oncorhynchus kisutch) and steelhead (Salmo gairdneri) spawning increased substantially, as well as the numbers of rearing coho, steelhead fry, and steelhead and cutthroat trout (Salmo clarki) parr. this study shows that similar degraded streams can be rehabilitated by properly designed enhancement programs. Such programs are effective and are needed to help ensure the protection of naturally spawning and rearing wild salmonid stocks and the survival of their young.

Codes: experi reach qual? instream substrate

House, R. A., and P. L. Boehne. 1986. Effects of instream structures on salmonid habitat and populations in Tobe Creek, Oregon. North American Journal of Fisheries Management 6: 38-46.

Tobe Creek, Oregon, was studied in 1982 and 1983 to compare physical and biological differences between a young-alder stream section logged and cleaned of large debris 20 years ago and a mature mixed-conifer section unlogged and containing large amounts of large woody debris. Stream enhancement techniques were used in 1982 to simulate large woody debris in the logged alder section to try to increase salmonid use. Large woody debris in the channel caused the development of secondary channels, meanders, pools, and undercut banks in the unlogged, mature-conifers, stream section. These elements were noticeably missing in the young-alder section. The mature-conifer section had more than twice as many pools and 10 times the amount of spawning gravel compared to the young-alder section. Salmonid biomass was significantly greater in the mature-conifer than the young-alder section prior to stream enhancement; after enhancement, no significant difference was found. Prior to enhancement, three times as many coho salmon (Oncorhynchus kisutch) and trout fry (cutthroat trout and steelhead) were living in the mature-conifer stream section. There was a positive correlation between coho salmon numbers and the presence of large woody debris. The study revealed that structure is most likely a more important factor than shade in governing a stream's capacity for producing salmonids.

Codes: experi reach quant ripar lwd instream

Howard-Williams, C., and S. Pickmere. 1999. Nutrient and vegetation changes in a retired pasture stream. Recent monitoring in the context of a long-term dataset. Science for Conservation [Sci. Conserv.] 5-34.

This report records water quality and vegetation changes in the Whangamata Stream, Lake Taupo catchment from 1995 to 1998. The data represent the latest three years of a 24-year study on changes to this pasture stream since riparian strips were established in 1976, to retire the margins of the stream from pastoral farming. This data set is unique in New Zealand for its continuity and allows a quantitative assessment of the extent and time scales of change in rehabilitation programmes of this nature. The process of rehabilitation of the stream was assisted by some plantings of native species among the pasture-grassed banks. During this three-year study period, the number of vascular plant species recorded in the stream and along the banks has increased from 119 to 148. Native plants made up 41% of the total. Woody species are invading the flax-dominated stream banks. The reaches of the stream which had the original plantings (c. 1976) have the highest number of species. The old pasture has proved very resistant to invasion and in many areas where assisted plantings have not occurred, extensive areas of rank grass comprising the original pasture species are still intact. The ability of the stream bank and channel flora to remove nutrients from the stream has been reduced over this three-year monitoring period, with nitrate and dissolved reactive phosphorus uptake in mid-summer now less than 15% of the mass flow of these nutrients. This compares with c. 90% removal in the mid-1980s. Total suspended solids show a strongly seasonal pattern with values increasing in winter and decreasing to low values (<5 g m super(-3)) in summer. A similar pattern was recorded in the late 1970s and early 1980s. The winter maximum TSS concentration in 1996 was very high (c. 70 g m super(-3)) coinciding with the Ruapehu eruption which blanketed much of the catchment in ash. The stream channel was essentially clear of the plant blockages which were a feature of the 1980s and early 1990s. The water flowed unimpeded below a dense cover of flax and toetoe, allowing easy access for spawning trout to the upper reaches of the stream. Fernbird, fantails, bellbird, pukeko were observed. The stream is now an increasingly important wildlife area. The role of the protected riparian strips has therefore changed over the years from a sediment and nutrient trapping mechanism to sediment control, with greatly enhanced wildlife values.

Codes: experi reach temporal nofish ripar graz substrate

Hubert, W. A., and S. J. Kozel. 1989. Testing of Habitat Assessment Models for Small Trout Streams in the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 9: 458-464.

The applicability of four habitat assessment models to small trout streams in the Medicine Bow National Forest were tested. All models yielded predictions of trout standing stocks or ratings of trout cover that were correlated with measured trout standing stocks; however, the predicted and measured standing stocks were not directly proportional, and not all model variables appeared to contribute to the predictions or ratings derived from the models. Among the habitat variables included in the four models, those most highly correlated with trout standing stocks were width-to-depth ratio, abundance of overhead bank cover, average stream width, and level of late-summer streamflow. It is hypothesized that much of the variation in measured habitat and model predictions among the study reaches was due to natural variation in habitat features associated with stream size and reach gradient. (Sand-PTT).

Codes: modeling reach habitat quant instream ifim warning hem

Hubert, W. A., R. P. Lanka, T. A. Wesche, F. Stabler, R. R. Johnson, C. D. Ziebell, D. R. Paton, P. F. Ffolliott, and R. H. Hamre. 1985. Grazing management influences on two brook trout streams in Wyoming. Pages 290-294. In Riparian ecosystems and their management : reconciling conflicting uses. R. R. Johnson, editors. USDA Forest Service general technical report RM, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Dept. of Agriculture, Fort Collins, CO.

Brook trout (Salvelinus fontinalis) abundance and instream habitat characteristics were evaluated in two rangeland streams. Heavily grazed and lightly grazed reaches of two streams with different grazing management were compared. Relationships between stream morphology, riparian zone characteristics, and trout abundance were observed.

Codes: reach experi multi graz ripar instream quant

Hubert, W. A., T. D. Marwitz, K. G. Gerow, N. A. Binns, and R. W. Wiley. 1996. Estimation of potential maximum biomass of trout in Wyoming streams to assist management decisions. North American Journal of Fisheries Management 16: 821-829.

Fishery managers can benefit from knowledge of the potential maximum biomass (PMB) of trout in streams when making decisions on the allocation of resources to improve fisheries. Resources are most likely to be expended on streams with high PMB and with large differences between PMB and currently measured biomass. We developed and tested a model that uses four easily measured habitat variables to estimate PMB (upper 90th percentile of predicted mean biomass) of trout (Oncorhynchus spp., Salmo trutta, and Salvelinus fontinalis) in Wyoming streams. The habitat variables were proportion of cover, elevation, wetted width, and channel gradient. The PMB model was constructed from data on 166 stream reaches throughout Wyoming and validated on an independent data set of 50 stream reaches. Prediction of PMB in combination with estimation of current biomass and information on habitat quality can provide managers with insight into the extent to which management actions may enhance trout biomass.

Codes: multi reach quant instream

Hughes, N. F. 1998. A model of habitat selection by drift-feeding stream salmonids at different scales. Ecology 79: 281-294.

Whole-stream size gradients of drift-feeding stream salmonids have received practically no attention, perhaps because the smaller-fish-upstream pattern that is thought to prevail is consistent with knowledge of habitat selection by other stream fish at the local scale. However, a rather counterintuitive larger-fish-upstream pattern has recently been documented for Arctic grayling (Thymallus arcticus) in Alaska and brown trout (Salmo trutta) in New Zealand, and habitat selection theory cannot explain these observations. My goal in this paper is to improve this situation by developing a model that predicts the distribution of a population of fish both within single pools and over the length of the entire river, as well as the behavioral mechanism responsible. The model uses information on invertebrate drift density and water temperature to predict the growth rate of different sizes of fish at the positions available in the stream. Fish then distribute themselves so that each individual occupies the most profitable position it can defend, with the largest fish winning any disputes. The model suggests that streams can be classified into categories based on the way temperature and drift density vary with the passage downstream. Each of these categories favors a different combination of size gradient and behavioral mechanism. A larger-fish-upstream pattern due to size-dependent habitat preference is predicted for streams with cool temperatures and low drift densities, conditions found in Arctic grayling streams. A larger-fish-upstream pattern due to competition between fish of different size is predicted in warm streams, irrespective of drift density, conditions found in many New Zealand trout streams. A smaller-fish-upstream pattern due to competition between fish of different size is expected in cool streams with high drift abundance; currently no data are available to test this prediction.

Codes: modeling basin reach migrat popdyn quant trophic wtemp

Hughes, N. F. 1998. Use of whole-stream patterns of age segregation to infer the interannual movements of stream salmonids: a demonstration with Arctic grayling in an interior Alaskan stream. Transactions of the American Fisheries Society 127: 1067-1071.

I show how patterns of whole-stream age segregation can be used to infer interannual movements of stream salmonids. First, estimates of recruitment and mortality rates for the population as a whole are calculated using data from fish sampled along the entire length of the river. These rates are used to simulate the age structure of an idealized population. Next, each age-class is divided among lower, middle, and upstream reaches, according to the proportions observed in the real population. Finally, the amount of interannual movement is estimated from the pattern of age segregation that would exist after 1 year if recruitment and mortality were allowed to act on the simulated population but no fish moved between reaches. Application of this technique to the "older-fish-upstream" distribution pattern of Arctic grayling Thymallus arcticus in an Alaskan river showed that substantial movements are required to maintain the observed pattern of age segregation. Annual emigration was estimated at 24%, 11%, and 0% for downstream, midriver, and upstream reaches respectively, estimated immigration was 2%, 30%, and 51%.

Codes: modeling basin reach migrat popdyn quant noenv

Hughes, N. F. 1999. Population processes responsible for larger-fish-upstream distribution patterns of Arctic grayling (Thymallus arcticus) in interior Alaskan runoff rivers. Canadian Journal of Fisheries and Aquatic Sciences 56: 2292-2299.

During the summer months, Arctic grayling (Thymallus arcticus) in Alaskan streams adopt a larger-older-fish-upstream distribution pattern. In this paper, data is analysed from two large interior Alaskan rivers to determine how population processes maintain this size and age gradient. These analyses support the hypothesis that age-phases recruitment and growth-dependent movement are primarily responsible for this distribution pattern. Age-phased recruitment describes the way that the mean age of fish recruiting to a reach increases upstream, from ages 0-1 in the lower river to ages 3-7 in the headwaters. This process begins with the concentration of spawning fish, and the resultant fry, in the lower reaches of the river. Downstream movement during the first year of life further concentrates young fish in the lower river. Over time, the distribution of this cohort broadens steadily as individuals move further upstream, so that fish recruiting to headwater reaches are 3-7 years old. This process contributes to both size and age gradients. Growth-dependent movement magnifies the size gradient by sorting fast-growing fish into the upper river and slow-growing fish into the lower river. This sorting results from the fact that individuals making long-distance upstream movements tend to have grown particularly rapidly that year, while individuals making long-distance downstream movements tend to have grown especially slowly that year. The hypothesis that age and size gradients are the result of whole-stream gradients in growth or mortality acting on a sedentary population was rejected. However, there was some evidence that fish did grow more slowly in the lowest 40 km of one river, although this made only a minor contribution to the size gradient, and growth rates were remarkably constant for the next 120 km. There was no suggestion that spatial variation in mortality rate contributed towards the size or age gradient, but natural and sampling variability could have obscurred small but significant differences between reaches.

Codes: modeling basin reach migrat popdyn quant noenv

Hunt, R. L. 1976. A long-term evaluation of trout habitat development and its relation to improving management-related research. TAFS 105: 361-364.

Responses of a wild brook trout (Salvelinus fontinalis) population to instream habitat development in a 0.7 km reach of Lawrence Creek were monitored for 7 years and compared to population data for the 3-year period prior to development. Mean annual biomass of trout, mean annual number of trout over 15 cm (legal size), and annual production increased significantly during the 3 years following development, but more impressive responses were observed during the second 3 years. Maximum number and biomass and number of legal trout did not occur until 5 years after completion of development. The peak number of brook trout over 20 cm was reached the sixth year after development. Where long-term studies of aquatic systems are needed to evaluate effects of environmental perturbations, it may be desirable to deliberately delay collection of posttreatment data. Such a start-pause-finish sequence of research would provide more valid and less costly evaluations and utilize the time of researchers more efficiently.

Codes: experi reach quant instream temporal

Hunt, R. L. 1988. A compendium of 45 trout stream habitat development evaluations in Wisconsin during 1953-1985. Technical Bulletin 162. Department of Natural Resources, Madison, Wisconsin. 80p.

Codes: review habitat reach quant instream

Hunt, R. L. 1992. Evaluation of Trout Habitat Improvement Structures in Three High-Gradient Streams in Wisconsin. Technical Bulletin 179. Department of Natural Resources, Madison, WI.

Eight types of in-channel trout habitat improvement structures were installed in 3 treatment zones (TZs) on portions of 3 Wisconsin trout streams having TZ gradient of approximately 1% (53-72 ft/mi). Structures were installed in the TZs at densities of 142/mi in Camp Creek, 100/mi in Devils Creek, and 208/mi in Twenty Mile Creek. Most of the wood and rock used to build the structures were gathered on site. Approximately 63% of the 72 test structures provided good or excellent trout habitat 4 yrs after installation. Two structure types, the channel constrictor and the cross-channel log/bank revetment, provided consistently good habitat for adult trout. Durability and functional performance of structures were much better in the 2 smaller TZs, on Camp Creek and Twenty Mile Creek, than in the largest TZ on Devils Creek. Only the channel constrictor and some bank cover logs functioned effectively in the Devils Creek TZ. Average cost per structure was $230 for the 2 smaller TZs on Camp and Twenty Mile creeks. Project cost per mile was approximately $38,000 (165 structures/mi). Wages for the professional crew accounted for 65% of the total cost. Abundance and biomass of wild brown trout (Salmo trutta) in April increased significantly in the Camp Creek TZ (1984 vs 1985-89 average), despite unfavorable below-normal streamflow regimes during the last 2-3 yrs of the post-installation period. Density of legal sized trout peaked at 457 trout/mi; biomass peaked at 344 lb/mi. Spring and fall densities of legal sized brown trout and total biomass in the spring and fall declined in the reference zone (RZ) during the post-installation period. At Devils Creek, densities of wild brook trout (Salvelinus fontinalis) and domestic brown trout in September were sparse in both the TZ and the RZ throughout the evaluation, due to lack of natural recruitment. At Twenty Mile Creek, legal sized wild brook trout (>/= 6 in) increased an average of 118% (to 185 trout/mi) in the TZ (1983-85 vs. 1986-89) and peaked at 392 trout/mi in September 1986. In the adjacent RZ, no change occurred in average density (189 trout/mi) of legal sized brook trout. Fisheries management recommendations include use of 7 of the 8 test structures to improve trout habitat in other small high gradient streams in Wisconsin and greater use of volunteer labor to reduce project costs. (Lantz-PTT).

Codes: experi multi reach quant instream economic temporal

Huusko, A., and T. Yrjaenae. 1997. Effects of instream enhancement structures on brown trout, Salmo trutta L., habitat availability in a channelized boreal river: A PHABSIM approach. Fisheries Management and Ecology [Fish. Manage. Ecol.] 4: 453-466.

Stream channel morphology and hydraulic conditions were measured before and after channel modification and boulder structure placements in a channelized boreal river to determine whether more favourable rearing habitat for brown trout, Salmo trutta L., was created. The assessment was performed using physical habitat simulation (PHABSIM) procedures based on summer and winter habitat preferences of brown trout for depth, velocity and substrate. The results showed that the availability of potential physical trout habitat can be increased in the study river at simulated low and moderate flow conditions by reconstruction of the river bed and placing instream boulder structures. The resulting diversity of depth and velocity conditions created a spatially more complex microhabitat structure. Improved habitat conditions were able to sustain a larger trout population. Hydraulic habitat models, like the PHABSIM framework, seem to be a suitable procedure to evaluate the benefits of physical habitat enhancement.

Codes: microhab qual? instream ifim hem

Irvine, J. R. 1987. Effects of Varying Flows in Man-Made Streams on Rainbow Trout (Salmo gairdneri Richardson) Fry. Pages 83-97. Regulated Streams: Advances in Ecology. Plenum Press, New York.

The construction in 1980 of the lower Waitaki River replicate stream channels in New Zealand allowed the possibility of studying regulated stream flow with controls in space and time. The purpose of this paper is to present results from two experiments in which the effects of flow changes, simulating conditions below a hydroelectric peaking plant, on rainbow trout fry emigration, growth and condition, production and habitat preferences were examined. Up to five-fold flow changes occurring twice daily, five days per week, had remarkably little effect on rainbow trout fry, illustrating how well-adapted fry are to varying discharge. Downstream emigration was not affected. However, in separate experiments at the replicate streams, downstream emigration of chinook or quinnat salmon fry was increased by fluctuating discharge. Varying flows resulted in significant weight gain for rainbow trout in the low density stream. Invertebrate drift densities sometimes increased during flow changes. Trout habitat preferences were similar in constant flowing and fluctuating streams. (See also W89-01736) (Lantz-PTT).

Codes: experi enclos habitat quant migrat lakehydro

Irvine, J. R., I. G. Jowett, and D. Scott. 1987. A test of the instream flow incremental methodology for underyearling rainbow trout, Salmo gairdnerii, in experimental New Zealand streams. New Zealand Journal of Marine and Freshwater Research 21: 35-40.

The instream flow incremental methodology predicts the potential amount of habitat in a stream, rather than fish biomass or numbers. The authors introduced rainbow trout (Salmo gairdneri) into stream channels next to the Waitaki River, South Island, New Zealand, and subsequently maintained a constant flow in these streams. The biomass of rainbow trout in individual riffles and pools of the streams was determined and related to the amount of usable area in these habitats calculated using the incremental methodology. Regardless of fish stocking density, rainbow trout biomass in late summer and early winter was not correlated with the amount of usable habitat.

Codes: experi habitat quant ifim warning hem

Isaak, D. J., and W. A. Hubert. 2000. Are trout populations affected by reach-scale stream slope? Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 468-477.

Reach-scale slope and the structure of associated physical habitats are thought to affect trout populations, yet previous studies confound the effect of stream slope with other factors that influence trout populations. The effect of stream slope on trout populations was isolated by sampling reaches immediately upstream and downstream of 23 marked changes in stream slope on 18 streams across Wyoming and Idaho. No effect of stream slope on areal trout density was observed, but when trout density was expressed volumetrically to control for differences in channel cross sections among reaches in different slope classes, the highest densities of trout occurred in medium-slope reaches, intermediate densities occurred in high-slope reaches, and the lowest densities occurred in low-slope reaches. The relative abundance of large trout was reciprocal to the pattern in volumetric trout density. Trout biomass and species composition were not affected by stream slope. Our results suggest that an assumption made by many fish-habitat models, that populations are affected by the structure of physical habitats, is at times untenable for trout populations in Rocky Mountain streams and is contingent upon the spatial scale of investigation and the population metric(s) used to describe populations.

Codes: multi experi reach quant instream warning

Jakober, M. J., T. E. McMahon, R. F. Thurow, and C. G. Clancy. 1998. Role of stream ice on fall and winter movements and habitat use by bull trout and cutthroat trout in Montana headwater streams. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 127: 223-235.

We used radiotelemetry and underwater observation to assess fall and winter movements and habitat use by bull trout Salvelinus confluentus and westslope cutthroat trout Oncorhynchus clarki lewisi in two headwater streams in the Bitterroot River drainage, Montana, that varied markedly in habitat availability and stream ice conditions. Bull trout and cutthroat trout made extensive (>1 km) downstream overwintering movements with declining temperature in the fall. Most fish remained stationary for the remainder of the study (until late February), but some fish made additional downstream movements (1.1-1.7 km) in winter during a low-temperature (less than or equal to 1 degree C) period marked by anchor ice formation. Winter movement was more extensive in the mid-elevation stream where frequent freezing and thawing led to variable surface ice cover and frequent supercooling (<0 degree C). Habitat use of both species varied with availability; beaver ponds and pools with large woody debris were preferred in one stream, and pools with boulders were preferred in the other. Trout overwintered in beaver ponds in large (N = 80-120), mixed aggregations. In both streams, both species decreased use of submerged cover following the formation of surface ice. Our results indicate that (1) continued activity by trout during winter is common in streams with dynamic ice conditions and (2) complex mixes of habitat are needed to provide suitable fall and winter habitat for these species.

Codes: multi reach qual migrat wtemp instream

Jenkins, T. M., Jr., S. Diehl, K. W. Kratz, and S. D. Cooper. 1999. Effects of population density on individual growth of brown trout in streams. Ecology 80: 941-956.

Some studies suggest that lotic populations of brown trout (Salmo trutta) are regulated through density-dependent mortality and emigration to the extent that mean growth rates of resident survivors are unrelated to trout densities. To test this, we studied the relationship between density and growth, mortality, and emigration of brown trout in two alpine streams and a set of stream channels in eastern California. We sampled trout at the scale of "segments" (5-31 m long riffles, runs, and pools) and "sections" (340-500 m in length) of Convict Creek over a 3-yr period. Trout were also sampled during 6 yr in seven 90-m sections of Mammoth Creek. For 2 yr, we manipulated trout densities in Convict Creek by removing trout from two sections and adding trout to two other sections. We also manipulated densities in seven 50-m stream channels, using a natural size distribution of trout in one year and underyearlings only in a second year. In both streams, average size (body length or mass) of underyearlings in fall was negatively related to trout density and was furthermore affected by sampling location and year. The strong, negative relationship between individual mass and density of trout could be detected at the spatial scale of whole sections, but not at the scale of individual segments. #(abstract incomplete)#

Codes: experi reach segment popdyn quant temporal noenv

Johnson, S. W., and J. Heifetz. 1985. Methods for assessing effects of timber harvest on small streams. Report NOAA-TM-NMFS-F/NWC73.

The methods used by the Northwest and Alaska Fisheries Center's Auke Bay Laboratory in assessing the effects of clear-cut logging on salmonid habitat and the effectiveness of buffer strips in protecting fish habitat during and after logging are described in detail. The methods have been used by the laboratory since 1982 to study fish populations and habitat in three different categories of streams in southeastern Alaska. The methods described include measurements of fish, periphyton, benthos, preferred fish habitats, and stream physical characteristics, such as discharge gradient, substrate, and water quality.

Codes: methods design ripar

Jones, K. K., and K. M. S. Moore. 2000. Habitat assessment in coastal basins in Oregon: Implications for coho salmon production and habitat restoration. Edited by E. E. Knudson, C. R. Steward, D. D. MacDonald, J. E. Williams and D. W. Reiser. CRC Press LLC, 2000 Corporate Blvd., NW Boca Raton FL 33431 USA

Quantitative habitat surveys have been conducted in western Oregon streams since 1990. Over 950 streams, a total of 6,000 kilometers, have been surveyed in coastal basins with the results organized into over 3,100 reaches characterized by land use, channel morphology, and valley form. The data have been compiled into a comprehensive database that describes key attributes of instream habitat, riparian structure, and channel morphology. The information was used to describe current status of habitat throughout the coastal basins and the potential to support coho salmon Oncorhynchus kisutch populations. Example maps and evaluations were developed for the Yaquina River watershed to describe and compare coho salmon habitat. The datasets will support sustainability because they can be used to estimate potential survival and production of juvenile coho salmon in coastal basins, to identify core habitats, for designing and evaluating monitoring programs, and for developing restoration strategies.

Codes: multi habitat reach segment nofish ripar instream datasource

Jowett, I. G., and M. J. Duncan. 1990. Flow variability in New Zealand rivers and its relationship to in-stream habitat and biota. New Zealand Journal of Marine and Freshwater Research 24: 305-317.

Flow variability indices were determined for 130 sites on New Zealand rivers and the sites were divided into groups based on these indices. Univariate and discriminant analyses were used to identify the catchment characteristics which contributed to flow variability. Accounted for a broad regional distribution of groups. Relationships were found between flow variability, and morphological and hydraulic characteristics. There were strong associations with periphyton communities and trout distribution and abundance and a weak association with benthic invertebrate communities. Water velocity was the most important hydraulic variable; it could be linked to changes in water temperature, benthic invertebrate and periphyton community structure, and trout distribution and abundance.

Codes: multi reach qual? instream trophic wtemp hydro

Jowett, J. G. 1990. Factors related to the distribution and abundance of brown and rainbow trout in New Zealand clear-water rivers. New Zealand Journal of Marine and Freshwater Research 24: 429-440.

Brown trout (Salmo trutta) and rainbow trout (Oncorhynchus mykiss) populations at 157 riverine sites throughout New Zealand were divided into groups based on species, size, and abundance. The groups were examined to determine significant differences in hydrological, water quality, water temperature, biological, in-stream habitat, and catchment variables between groups. A discriminant model was developed with nine environmental factors which correctly classified 72% of a subset of 65 sites. Fish species distribution was related to climatic (water temperature), geographical, and hydrological factors, whereas fish abundance was determined by factors relating to flow variability, river gradient, in-stream habitat, and the presence of lakes in the catchment.

Codes: multi reach quant? instream wtemp watqual lulc hydro lakehydro

Jowett, J. G. 1992. Models of the abundance of large brown trout in New Zealand rivers. North American Journal of Fisheries Management 12: 417-432.

Multiple-regression models of the abundance of brown trout Salmo trutta larger than 200 mm total length were developed from combinations of hydrological, catchment, physical, water quality, and benthic invertebrate biomass variables in New Zealand rivers. Three hydrological and catchment variables explained 44.4% of the variation in trout abundance, and benthic invertebrate biomass alone explained almost 45%. Together, invertebrate biomass and weighted usable area (WUA) for adult brown trout drift-feeding habitat explained 64.4% of the variation in trout abundance. The model best suited to the application of the instream flow incremental methodology (IFIM) explained 87.7% of the variation in brown trout abundance at 59 sites. Two variables were calculated with flow data: WUA for food production at median flow and WUA for adult brown trout drift-feeding habitat at mean annual low flow. Other variable within the model either did not vary with flow or varied little. This study demonstrates that WUA is an important determinant of adult brown trout abundance, refuting one of the major criticisms of IFIM.

Codes: multi reach quant instream wtemp watqual lulc trophic hydro ifim hem

Jutila, E., A. Ahvonen, and M. Laamanen. 1999. Influence of environmental factors on the density and biomass of stocked brown trout, Salmo trutta L., parr in brooks affected by intensive forestry. Fisheries Management and Ecology [Fish. Manage. Ecol.] 6: 195-205.

The influence of environmental factors on the density and biomass of stocked brown trout, Salmo trutta L., parr was studied in brooks subjected to intensive forestry in the Isojoki river basin, western Finland. Multivariate regression analysis showed that 69% of the variation in the population density of parr was determined by five variables: (1) mean water depth; (2) the abundance of pools; (3) stony bottom substrates with stones sized between 2 and < 10 cm in diameter; (4) undercut banks; and (5) the percentage of shading by trees. Correspondingly, 57% of the variation in the biomass of parr was determined by three variables: (1) mean water depth; (2) the abundance of pools; and (3) benthic vegetation. Dredging of the brooks and forest ditching had the most harmful consequences for the nursery habitats of brown trout parr. Measures for the rehabilitation of brown trout production in these brooks are discussed.

Codes: multi reach quant instream substrate ripar

Kareiva, P., M. Marvier, and M. McClure. 2000. Recovery and management options for spring/summer chinnook salmon in the Columbia River Basin. Science 290: 977-979.

Construction of four dams on the lower Snake River (in northwestern United States) between 1961 and 1975 altered salmon spawning habitat, elevated smolt and adult migration mortality, and contributed to severe declines of Snake River salmon populations. By applying a matrix model to long-term population data, we found that (i) dam passage improvements have dramatically mitigated direct mortality associated with dams; (ii) even if main stem survival were elevated to 100%, Snake River spring/summer chinook salmon (Oncorhynchus tshawytscha) would probably continue to decline toward extinction; and (iii) modest reductions in first-year mortality or estuarine mortality would reverse current population declines.

Codes: modeling popdyn quant hydro noenv

Keeley, E. R. 2000. A experimental analysis of territory size in juvenile steelhead trout. Animal Behaviour 59: 477-490.

I experimentally manipulated levels of food abundance and density of competitors to determine how these factors influence the territory size of juvenile steelhead trout, Oncorhynchus mykiss. Steelhead trout were held in artificial stream channels and I followed cohorts that were fed at one of three levels of food abundance and stocked at one of three levels of fish density. By measuring territory size over a 2-month period, while the fish were growing, I was also able to assess the effects of body size in determining the size of a territory. Defended and foraging areas were similar in absolute size, but the frequency of space use was different for defence than for foraging. As predicted, territory size decreased with increasing levels of food abundance and increased with decreasing levels of fish density. In addition, territory size increased with increasing body size even after controlling the effects of food abundance and competitor density. In comparison to previous studies, territory size of steelhead trout changed more dramatically in response to changing levels of food and competitors. For territorial animals with indeterminate growth, territory size is not only adjusted as a trade-off between the costs and benefits of defence, but also with respect to body size due to increasing metabolic demands as individuals grow.

Codes: experi microhab quant trophic

Keeley, E. R., P. A. Slaney, and D. Zaldokas. 1996. Estimates Of Production Benefits For Salmonid Fishes From Stream Restoration Initiatives. Watershed Restoration Management Report No. 4. Watershed Restoration Program. Ministry of Environment, Lands and Parks and Ministry of Forests, British Columbia

#Takes published data as is, without noting methods of population density estimation or scale of estimates (e.g. length of stream sampled and its order). Uses data dominated by summer samples, but does not consider seasonal effects or attraction effects of retsored reaches, which would compromise extrapolations to whole stream or adult returns. Looks at species separately. Analyses by paired-t across studies without investigating interactions (which is not possible if each study is reduced to a pair opf mean values). Given the foregoing, finds significant increases in local densities due to habitat restoration, and taken at that unspecified local scale, the results are convincing and encouraging.#

Codes: review exper quant reach offchann

Keith, R. M., T. C. Bjornn, W. R. Meehan, N. J. Hetrick, and M. A. Brusven. 1998. Response of Juvenile Salmonids to Riparian and Instream Cover Modifications in Small Streams Flowing through Second-Growth Forests of Southeast Alaska. Transactions of the American Fisheries Society 127: 889-907.

We manipulated the canopy of second-growth red alder Alnus rubra and instream cover to assess the effects on abundance of juvenile salmonids in small streams of Prince of Wales Island, southeast Alaska, in 1988 and 1989. Sections of red alder canopy were removed to compare responses of salmonids to open- and closed-canopy sections. At the start of the study, all potential instream cover was removed from the study pools. Alder brush bundles were then placed in half the pools to test the response of juvenile salmonids to the addition of instream cover. Abundance of age-0 coho salmon Oncorhynchus kisutch decreased in both open- and closed-canopy sections during both summers, but abundance decreased at a higher rate in closed-canopy sections. More age-0 Dolly Varden Salvelinus malma were found in open-canopy sections than in closed-canopy during both summers. Numbers of age-1 and older coho salmon and Dolly Varden were relatively constant during both summers, and there was no significant difference in abundance detected between open- and closed-canopy sections. Abundance of age-0 coho salmon decreased in pools with and without additional instream cover during both summers. Abundance of age-1 and older coho salmon and age-0 Dolly Varden did not differ significantly in pools with or without added cover during either summer. Abundance of age-1 and older Dolly Varden was higher in pools with added instream cover than in pools without cover during both summers. Age-0 coho salmon decreased in abundance throughout the summer in both years. Emigration was measured in 1989 and accounted for most of the decrease in abundance. Age-0 coho salmon emigrants were significantly smaller than age-0 coho salmon that remained in the stream.

Codes: multi experi reach quant migrat ripar lwd

Keller, C. R., and K. P. Burnham. 1982. Riparian Fencing, Grazing, and Trout Habitat Preference on Summit Creek, Idaho. North American Journal of Fisheries Management 2: 53-59.

In 1975, 3.2 km of Summit Creek, Idaho were fenced by the Bureau of Land Management to exclude livestock from the riparian area. Six stream sections were electrofished in 1979 to determine differences in trout abundance, size, and growth between grazed and ungrazed stream sections. Electrofishing station were paired by habitat type. There were more trout in ungrazed sections than in grazed sections in all three habitat types sampled. With one exception, there were more catachablesized (200 mm long or longer) rainbow trout (Salmo gairdneri) and brook trout (Salvelinus fontinalis) in the ungrazed area than in the grazed area. There was also evidence that the average size of the fish was less in grazed sections. Fish population data were not collected prior to fencing; therefore it cannot be firmly concluded that the trout population increased within the livestock enclosure as a result of fencing the riparian area. However, the combined results of previous trout habitat improvements documented for Summit Creek, as a result of the fencing, and this study support the conclusion that trout prefer stream areas in ungrazed habitat over grazed habitat.

Codes: reach experi graz quant

Kelly-Quinn, M., D. Tierney, W. Roche, and J. J. Bracken. 1996. Distribution and abundance of trout populations in moorland and afforested upland nursery streams in County Wicklow. Biology and Environment 96B: 127-139.

Codes: multi reach quant ripar

Kennedy, G. J. A. 1988. Stock enhancement of Atlantic salmon (Salmo salar L.). Edited by D. Mills and D. Piggins. , 345-372 p.

The efficacy of different enhancement techniques for Atlantic salmon (Salmo salar) is evaluated. Stocking techniques. The relative merits and drawbacks of stocking with green and eyed ova, unfed and fed fry, parr and smolts is discussed, along with an assessment of appropriate stocking densities. Recommendations for further research are made in a number of areas. Alternative enhancement techniques are discussed under the headings of stream remedial measures, adult transfers and lake rearing. It is concluded that more research is required into problems associated with the latter before definitive recommendations can be produced. Successes with adult transfers in Canada suggest that there is scope for investigation of the applicability of this technique elsewhere.

Codes: review quant reach noenv

Kennedy, G. J. A., and C. D. Strange. 1980. Population changes after two years of salmon (Salmo salar L.) stocking in upland trout (Salmo trutta L.) streams. J. Fish. Biol. 17: 577-586.

The survival of salmon stocked in upland trout streams in the presence of salmon parr was found to be only about half the value recorded when trout alone made up the resident stock. Changes in the trout population were also recorded following the 2 yr of salmon stocking, and these suggested that the presence of salmon parr may also influence trout fry survival. The findings are discussed in the context of habitat competition and total stream holding capacity.

Codes: multi experi reach quant sppinter noenv

Kershner, J. L., C. M. Bischoff, and D. L. Horan. 1996. Comparison of population, habitat, and genetic characteristics of Colorado River cutthroat trout in wilderness vs. non-wilderness streams in the Uinta mountains. Annual Meeting of the Western Division of the American Fisheries Society, 14-18 Jul 1996. Eugene, OR (USA). American Fisheries Society, Oregon Chapter, PO Box 722, Corvallis, OR 97339, Contact individual authors directly.

Codes: experi multi reach qual

Kjelson, M. A., and P. L. Brandes. 1989. The use of smolt survival estimates to quantify the effects of habitat changes on salmonid stocks in the Sacramento-San Joaquin rivers, California. Edited by C. D. Levings, L. B. Holtby and M. A. Henderson. 100-115 p.

Mark-recapture studies of smolt survival in the Sacramento-San Joaquin Delta of California provides empirical data on the effects of water development on fall-run chinook salmon (Oncorhynchus tshawytscha). Recoveries of coded-wire tagged hatchery fish from the ocean troll fishery and estuarine trawling yielded two survival measures that were positively correlated ($r = 0.90$). Smolt survival from both measures were highly correlated to river flow, temperature, and percent diversion. Survival of fish exposed to diversion was about 50% less than those not exposed. Study designs to quantify the independent effects of temperature on survival and the survival of wild smolts are presented.

Codes: basin popdyn hydro wtemp

Klassen, H. D., and T. G. Northcote. 1986. Stream Bed Configuration and Stability Following Gabion Weir Placement to Enhance Salmonid Production in a Logged Watershed Subject to Debris Torrents. Canadian Journal of Forest Research 16: 197-203.

Tandem V-shaped gabion weirs for improving spawning habitat for salmon were installed to replace large organic debris at three sites below the terminus of a debris torrent in Sachs Creek, Queen Charlotte Islands. Stream conditions were compared between gabion and nearby control sites. The stability of added and entrapped gravel at all gabion sites was poor over the first winter and excessive scour threatened the integrity of the upstream steeper (3%) slope gabion site. However, the two gabion sites at lower (1%) slope successfully stabilized spawning gravel in the second year after installation, probably through a reduction in the local slope gradient and self-armouring of the high flow channels. Higher summer densities of juvenile coho slamon and steelhead trout were recorded at the gabion sites compared with the control sites. Underyearling coho fry were also significantly larger at gabion sites than at control sites. Improved rearing habitat was created for coho juveniles by the gabions, a result of increased pool area and cover. (Author 's abstract).

Codes: experi quant? instream substrate

Knapp, R. A., and K. R. Matthews. 1996. Livestock grazing, golden trout, and streams in the Golden Trout Wilderness, California: impacts and management implications. North American Journal of Fisheries Management 16: 805-820.

Impacts of livestock grazing on California golden trout Oncorhynchus mykiss aguabonita and their habitat were studied inside and outside of livestock exclosures in the Golden Trout Wilderness, California. In two consecutive years, the majority of stream physical characteristics showed large differences between grazed and ungrazed areas, and the directions of these differences were consistent with the recovery of exclosed streams and riparian areas from impacts caused by livestock grazing. Ungrazed areas consistently had greater canopy shading, stream depths, and bank-full heights and smaller stream widths than grazed areas. California golden trout were very abundant in the study sites; their densities and biomasses were among the highest ever recorded for stream-dwelling trout in the western United States. California golden trout density and biomass per unit area were significantly higher in ungrazed than in grazed areas in three of four comparisons. Differences between grazed and ungrazed areas were less consistent when density and biomass were calculated on the basis of stream length. Our results suggest that current levels of livestock grazing are degrading the stream and riparian components of the study meadows to the detriment of golden trout populations.

Codes: reach experi graz ripar quant

Knapp, R. A., and H. K. Preisler. 1999. Is it possible to predict habitat use by spawning salmonids? A test using California golden trout (Oncorhynchus mykiss aguabonita). Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 56: 1576-1584.

In this study, nonparametric logistic regression was used to determine what habitat features were associated with the locations chosen by spawning California golden trout (Oncorhynchus mykiss aguabonita). From this nonparametric model, a parametric model was developed that incorporated the habitat features most strongly associated with spawning sites and this model was used to calculate the probability of use by spawning golden trout for specific stream locations. The overall nonparametric model was highly significant and explained 62% of the variation in spawning location. Four of the eight habitat variables, substrate size, water depth, water velocity, and stream width, had highly significant effects and alone explained 59% of the variation in spawning location. Results of a cross-validation procedure indicated that the parametric model generally provided a good fit to the data. Results indicate that location-specific probabilities of use were predictable based on easily measured habitat characteristics and that nonparametric regression, an approach still rarely used in ecological studies, may have considerable utility in the development of fish-habitat models. Given the escalating pace at which fish habitats are being altered, such models are increasingly important in predicting the effects of these alterationson populations.

Codes: reach spawn qual instream substrate modeling

Knapp, R. A., V. T. Vredenburg, and K. R. Matthews. 1998. Effects of stream channel morphology on golden trout spawning habitat and recruitment. Ecological Applications [Ecol. Appl.] 8: 1104-1117.

Populations of stream-dwelling salmonids (e.g., salmon and trout) are generally believed to be regulated by strong density-dependent mortality acting on the age-0 life stage, which produces a dome-shaped stock-recruitment curve. Although this paradigm is based largely on data from anadromous species, it has been widely applied to stream-resident salmonids despite the fact that the processes limiting or regulating stream-resident populations remain poorly understood. The purpose of the present study was to determine whether stream channel morphology affects the availability of spawning habitat for California golden trout, and whether spawning habitat availability influences the production of age-0 trout and recruitment into the adult population. Wide stream reaches contained significantly more spawning habitat and a higher density of nests and age-0 trout than did narrow reaches. In contrast to the idea that salmonid populations are regulated by density-dependent mortality of age-0 fish, we found that the mortality of age-0 trout was largely density independent. In addition, over most of the range of observed fish densities, the density of a particular cohort was positively correlated between years for age-0, age-1, and age-2 trout. Therefore, our golden trout study population was limited by spawning habitat, with spawning habitat availability influencing the production of age-0 trout as well as recruitment into the adult population. Grazing by cattle has widened the study streams, and our current findings help to explain why stream sections subject to grazing had more spawning habitat and higher golden trout densities than ungrazed sections. Individual growth rates of golden trout are apparently negatively density dependent, and these grazing-related increases in trout density have likely resulted in decreased growth rates. Our study demonstrates that it is only by gaining an understanding of how processes operate that we will be able to predict the effects of habitat alteration on populations.

Codes: experi reach graz quant spawn popdyn

Knudsen, E. E., and S. J. Dilley. 1987. Effects of riprap bank reinforcement on juvenile salmonids in four western Washington streams. North American Journal of Fisheries Management 7: 351-356.

Summer and fall juvenile salmonid populations in five pairs of stream sections were estimated shortly before and after construction of flood and erosion control projects. All five projects included bank reinforcement with rock riprap and three included streambed alterations. Juvenile coho salmon Oncorhynchus kisutch, juvenile steelhead Salmo gairdneri, and cutthroat trout Salmo clarki were apparently adversely affected by construction in the three smaller, and most severely altered, stream sections. Negative short-term effects of construction appeared to increase with severity of habitat alteration, to decrease with increase in stream size, and to decrease with increasing fish size.

Codes: experi multi reach quant substrate instream

Kocik, J. F., and C. P. Ferreri. 1998. Juvenile production variation in salmonids: population dynamics, habitat, and the role of spatial relationships. Canadian Journal of Fisheries and Aquatic Sciences 55: 191-200.

Anadromous Atlantic salmon (Salmo salar) exhibit a complex life history that requires the use of haitats that span several different temporal and spatial scales. While fisheries scientists have investigated the various elements of habitat and how they affect Atlantic salmon growth and survival, these studies typically focus on requisite requirements for a single life history stage. Current advances in the understanding of salmonid populations in lotic systems indicates that ignoring the spatial positioning of different habitats and dispersal capabilities of fish between them may affect estimates of habitat quality and production of juvenile Atlantic salmon. Using the concepts of juxtaposition and interspersion, it is hypothesized that discrete functional habitat units (FHU) occur within river systems and that the spatial structure of FHU affects fish production. Utilizing a simulation model, it is illustrated how modeling FHU structure of spawning and rearing habitat in a river system can improve understanding of juvenile Atlantic salmon production dynamics. The FHU concept allows a flexible approach to more comprehensive analyses of the impacts of habitat alterations, seasonal habitat shifts, and spatial ecology of salmonids at various scales.

Codes: philosophy habitat reach migrat modeling temporal

Kocik, J. F., and W. W. Taylor. 1996. Effect of juvenile steelhead on juvenile brown trout habitat use in a low-gradient Great Lakes tributary. Transactions of the American Fisheries Society 125: 244-252.

We investigated habitat use of wild brown trout Salmo trutta in Gilchrist Creek, Michigan, with and without a parallel cohort of introduced steelhead Oncorhynchus mykiss. This stream is typical of the region, having a low-gradient, stable discharge and a high sand bedload. By snorkeling, we evaluated seasonal habitat use in two stream reaches before and after steelhead introduction to one of the reaches. Age-0 brown trout occupied stream margins soon after emergence, using cover provided by aquatic vegetation growing on sand and silt substrates. By summer and fall, brown trout moved into deeper water and used more diverse cover types. From summer to fall, the smaller age-0 steelhead used lower current velocities than did age-0 brown trout. Similar water depth, substrate, and cover were used by the two species. At the densities studied, age-0 brown trout habitat use did not change in response to the presence of age-0 steelhead. We believe that three factors minimized the effect of steelhead: (1) the larger size of the brown trout, which gave them a competitive advantage; (2) vertical habitat segregation with steelhead suspended in the water column and brown trout near or at the bottom; and (3) temporal differences in habitat ontogeny with shifts of older, larger fish to deeper, faster water. These factors may permit these two species to coexist in low-gradient rivers.

Codes: experi reach quant sppinter instream substrate

Kondolf, G. M. 1994. Livestock grazing and habitat for a threatened species: land-use decisions under scientific uncertainty in the White Mountains, California, USA. Environmental Management 18: 501-509.

The North Fork of Cottonwood Creek, in the White Mountains, Inyo National Forest, California, is a critically important refuge for the Paiute cutthroat trout (Oncorhynchus clarki seleniris), a federally listed threatened species. Habitat for these fish appears to be limited by excessive levels of fine sediment in the channel, and livestock grazing of riparian meadows has been implicated in delivery of sediment to the channel. However, the relationships between land use and sediment yield have not been conclusively determined, in large part because there are no historically ungrazed sites to serve as long-term controls. Accordingly, land-use decisions must be made under scientific uncertainty. To reduce erosion and sedimentation in the stream, the Forest Service spent approximately US$260,000 from 1981 to 1991 to repair watershed damage from livestock grazing, prevent livestock from traversing steep banks, and limit livestock access to the channel. Throughout this period, livestock grazing has continued on these lands, yielding less than $12,000 in grazing fees. In revising its Allotment Management Plan for the basin, the Forest Service rejected the "no-grazing" alternative because it was inconsistent with its Land and Resource Management Plan, which specifies there is to be no net reduction of grazing.

Codes: substrate graz qual economic

Korman, J., and P. S. Higgins. 1997. Utility of escapement time series data for monitoring the response of salmon populations to habitat alteration. Canadian Journal of Fisheries and Aquatic Sciences 54: 2058-2067.

We provide a quantitative examination of the utility of escapement data for monitoring changes in salmonid populations caused by habitat alterations. We used Monte Carlo simulations to determine the precision, duration of monitoring, and the effect size required to achieve acceptable statistical inferences based on before-after (BA) and before-after-control-impact (BACI) comparisons. There was generally less than a 50% chance of detecting a population response unless the population change was large (more than a twofold increase) or the post-treatment monitoring period long (>10 years). Statistical power was improved by increasing the precision of escapement estimates, but the extent of improvement was dependent on the magnitude of population response to treatment, the duration of monitoring, and the extent of natural variability in abundance. BACI comparisons generally had a 10-15% lower probability of detecting a population change than BA comparisons unless the degree of covariation in survival rates between control and treatment stocks was very strong. Autocorrelation in error, simulating patterns of high and low survival rates over time, generally reduced power by 5-15%. Our results identify the conditions where escapement information can be used to make reliable inferences on salmonid population changes and provides a means for evaluating alternative monitoring designs.

Codes: modeling design risk

Kozel, S. J., and W. A. Hubert. 1989. Factors influencing the abundance of brook trout (Salvelinus fontinalis) in forested mountain streams. Journal of freshwater ecology. La Crosse, WI 5: 113-122.

Physical and biological factors that appear to influence standing stocks (kg/ha) of brook trout (Salvelinus fontinalis) were identified in the Medicine Bow National Forest, Wyoming, for 32 forested reaches of mountain streams in drainages unaltered by human activity. Brook trout abundance declined as stream size increased. This decline appeared to be related to at least two factors--decline in habitat quality with increasing stream size and interaction with brown trout (Salmo trutta) at lower elevations. The greatest variation in brook trout abundance (R super(2) = 0.77) was accounted for by drainage basin area and elevation of the stream reach. (DBO).

Codes: multi reach quant instream substrate lulc

Kozel, S. J., and W. A. Hubert. 1989. Testing of habitat assessment models for small trout streams in the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 9: 458-464.

We tested the applicability of four habitat assessment models to small trout streams in the Medicine Bow National Forest. All models yielded predictions of trout standing stocks or ratings of trout cover that were correlated with measured trout standing stocks; however, the predicted and measured standing stocks were not directly proportional, and not all model variables appeared to contribute to the predictions or ratings derived from the models. Among the habitat variables included in the four models, those most highly correlated with trout standing stocks were width-to-depth ratio, abundance of overhead bank cover, average stream width, and level of late-summer streamflow. We hypothesize that much of the variation in measured habitat and model predictions among our study reaches was due to natural variation in habitat features associated with stream size and reach gradient. Our results identify the habitat features that appear to drive the habitat models when applied to small trout streams that have been minimally altered by man in the central Rocky Mountains.

Codes: multi reach quant instream ifim warning method hem

Kozel, S. J., W. A. Hubert, and M. G. Parsons. 1989. Habitat features and trout abundance relative to gradient in some Wyoming streams. Northwest Science 63: 175-182.

Channel gradient has been shown to have a negative relation to trout standing stocks indicating that separation of stream channels into gradient classes may provide a better understanding of the relationships between habitat and trout abundance. Our major objective was to determine if there are significant differences in habitat features and standing stocks of trout > 100 mm between two classes of channel gradient, low (0.1-1.4% channel slope) and moderate (1.5-4.0%). We also determined statistical relations between habitat features and trout standing stocks in each class of channel for unaltered streams on the Medicine Bow National Forest, Wyoming. Low-gradient reaches were found to have deeper nearshore water depths, more undercut banks, and more trench pools than moderate-gradient reaches, while moderate-gradient reaches had more cobble substrate, dammed pools formed by woody debris, and plunge pools. The mean standing stock was 267 kg/ha in low-gradient reaches and 102 kg/ha in moderate-gradient reaches. Habitat features correlated with trout standing stocks differed between the two gradient classes.

Codes: multi reach quant instream substrate

Kruse, C. G., W. A. Hubert, and F. J. Rahel. 1997. Geomorphic influences on the distribution of Yellowstone cutthroat trout in the Absaroka Mountains, Wyoming. TAFS 126: 418-427.

Influences of large-scale abiotic, geomorphic characteristics on distributions of Yellowstone cutthroat trout Oncorhynchus clarki bouvieri are poorly understood. We sampled 151 sites on 56 perennial streams in the Greybull-Wood river drainage in northwestern Wyoming to determine the effects of geomorphic variables on Yellowstone cutthroat trout distributions. Channel slope, elevation, stream size, and barriers to upstream movement significantly influenced the presence and absence of Yellowstone cutthroat trout. Wild populations of Yellowstone cutthroat trout were not found upstream of barriers to fish migration, at sites with channel slopes of 10% or greater, or at elevations above 3,182 m. Based on channel slope alone, logistic regression models correctly classified presence or absence of Yellowstone cutthroat trout in 83% of study sites. The addition of elevation and stream size in the models increased classification to 87%. Logistic models tested on an independent data set had agreement rates as high as 91% between actual and predicted fish presence. Large-scale geomorphic variables influence Yellowstone cutthroat trout distributions, and logistic functions can predict these distributions with a high degree of accuracy.

Codes: multi reach qual instream lulc

Kucera, P. A., and D. B. Johnson. 1986. Biological and Physical Inventory of the Streams within the Nez Perce Reservation: Juvenile Steelhead Survey and Factors that Affect Abundance in Selected Streams in the Lower Clearwater River Basin, Idaho. DE87-009919. DOE Report No. DOE/BP/10068--T1. National Technical Information Service, Springfield VA. 22161.

A biological and physical inventory of selected tributaries in the lower Clearwater River basin was conducted by the Nez Perce Tribe Department of Fisheries Management during 1983 and 1984. The purpose of the juvenile steelhead study was to collect information for the development of alternatives and recommendations for the enhancement of the anadromous fish resources in streams on the Nez Perce Reservation. Five streams within the Reservation were selected for study: Bedrock and Cottonwood Creeks were investigated over a two years period (1983-1984) and Big Canyon, Jacks and Mission Creeks were studied for one year (1983). Biological information was collected and analyzed on the density, biomass, production and outmigration of juvenile summer steelhead trout. Physical habitat information was collected on available instream cover, stream discharge, stream velocity, water temperature, bottom substrate, embeddedness and stream width and depth. The present report focuses on the relationships between physical stream habitat and juvenile steelhead trout abundance. The downstream outmigration of juvenile steelhead principally occurred during the spring and fall periods. Fall pulses in downstream movement were generally reflected in short term increases in yearling fish densities at lower stream sampling stations. Abundance of yearling steelhead in the spring of 1984 (May-June) actually increased as the smolt outmigration was completed The redistribution of non-smolt age I+ fish into the sample station locations, apparently accounts for the increase. Genetic stock assessment of four Reservation stream steelhead populations indicated that two of the streams may have been affected by Dworshak Hatchery steelhead. The remaining two populations were more similar to steelhead from the grande Ronde, Imnaha and Salmon River systems. (Lantz-PTT).

Codes: multi quant migrat instream wtemp substrate

Kwak, T. J., and T. Waters. 1997. Trout production dynamics and water quality in Minnesota streams. TAFS 126: 35-48.

We sampled fish assemblages and quantified production dynamics of brook trout Salvelinus fontinalis, brown trout Salmo trutta, and rainbow trout Oncorhynchus mykiss in 13 southeastern Minnesota streams during 1988-1990 to examine the influence of water quality on fish populations in fertile trout streams. Fish assemblages in 15 stream reaches were abundant, but low in diversity; 13 species were collected. Parameter means (ranges) over the reaches were species richness, 4.1 (1-8); density, 29,490 (1,247-110,602) fish/ha; and biomass, 253.5 (49.6-568.6) kg/ha. Means (ranges) for salmonids were annual mean density, 2,279 (343-8,096) fish/ha; annual mean biomass, 162.0 (32.5-355.5) kg/ha; and annual production, 155.6 (36.7-279.6) kg /ha. Salmonid production and mean biomass were greater during the spring-fall interval than during fall-spring; young cohorts (ages 0-1) contributed the greatest proportion to population biomass and production. Salmonid annual production-to-mean-biomass ratio (P/B) averaged 1.06 (0.64-1.42), and means were significantly different among species (1.03 for brown trout, 1.54 for brook trout, and 1.92 for rainbow trout). A significant linear model was developed that describes P/B as an inverse function of population age structure and may be used to improve accuracy in approximations of annual production from mean biomass. Fish density, biomass, or production were not correlated with eight water quality variables describing ionic and nutrient content in these streams, but when data from other United States streams with a wide range in alkalinity were incorporated, salmonid production was strongly, positively correlated with alkalinity. The wide range in fish population and production statistics and their lack of correlation with water quality suggest that no uniform fish carrying capacity exists among these streams and that factors other than water fertility limit fish density, biomass, and productivity at this spatial scale, but the overall maximum production rate in the region may be governed by water quality.

Codes: multi reach popdyn quant watqual noenv

L'Abee-Lund, J. H., and T. G. Heggberget. 1995. Density of juvenile brown trout and Atlantic salmon in natural and man-made riverine habitats. Ecology of Freshwater Fish 4: 138-140.

The density of juvenile brown trout (Salmo trutta L.) and Atlantic salmon (Salmo salar L.) was significantly higher along river bank areas protected against erosion than along natural river banks in the River Gaula, Central Norway. A habitat shift appeared in Atlantic salmon, and a behavioural shift was demonstrated by brown trout from August to October. The effect of habitat on densities of juvenile salmonids should be taken into account as mitigation measures on eroded river banks and when assessing fish production in rivers.

Codes: experi reach quant instream ripar

La Voie, W. J. I., and W. A. Hubert. 1997. Late summer and fall use of stream margins of young-of year brown trout in a high-elevation stream. Journal of Freshwater Ecology [J. Freshwat. Ecol.] 12: 291-302.

The authors determined the relative abundance of young-of-year (YOY) brown trout (Salmo trutta) from late summer to fall during day and night in stream margin habitats of Douglas Creek, Wyoming. No significant differences in relative abundance were observed from August 14 through October 26. Few YOY brown trout were observed during the day over the entire sampling period, but significantly greater numbers were seen at night. Within stream margins, YOY brown trout of 36-75 mm total length primarily resided in concealment cover among interstices of cobble during the day and emerged at night. Because no significant change in relative abundance was observed throughout the study period, it is concluded that a shift to winter habitat did not occur up until three days prior to ice formation when the diurnal range in water temperature was 2.5-7.5 degree C.

Codes: experi habitat qual? instream substrate

Lee, D. C., and B. E. Rieman. 1997. Population viability assessment of salmonids by using probabilistic networks. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 17: 1144-1157.

Public agencies are being asked to quantitatively assess the impact of land management activities on sensitive populations of salmonids. To aid in these assessments, we developed a Bayesian viability assessment procedure (BayVAM) to help characterize land use risks to salmonids in the Pacific Northwest. This procedure incorporates a hybrid approach to viability analysis that blends qualitative, professional judgment with a quantitative model to provide a generalized assessment of risk and uncertainty. The BayVAM procedure relies on three main components: (1) an assessment survey in which users judge the relative condition of the habitat and estimate survival and reproductive rates for the population in question; (2) a stochastic simulation model that provides a mathematical representation of important demographic and environmental processes; and (3) a probabilistic network that uses the results of the survey to define likely parameter ranges, mimics the stochastic behavior of the simulation model, and produces probability histograms for average population size, minimum population size, and time to extinction. The structure of the probabilistic networks allows partitioning of uncertainty due to ignorance of population parameters from that due to unavoidable environmental variation. Although based on frequency distributions of a formal stochastic model, the probability histograms also can be interpreted as Bayesian probabilities (i.e., the degree of belief about a future event). We argue that the Bayesian interpretation provides a rational framework for approaching viability assessment from a management perspective. The BayVAM procedure offers a promising step toward tools that can be used to generate quantitative risk estimates in a consistent fashion from a mixture of information.

Codes: modeling risk philosophy popdyn

Leidholt-Bruner, K., D. E. Hibbs, and W. C. McComb. 1992. Beaver dam locations and their effects on distribution and abundance of coho salmon fry in two coastal Oregon streams. Northwest Science 66: 218-223.

Beaver (Castor canadensis) dams and coho salmon (Oncorhynchus kisutch) fry were examined for their relationships in two coastal Oregon streams in 1987. Our initial spring survey of 19 km of stream found only one dam still complete after winter. By autumn, the number of dams had increased to 1.1 and 1.2 per km on the two streams. Beaver dams increased summer pool habitat 7 to 14% over unmodified conditions. Although density of coho (per m super(2) and m super(3)) was similar among pool types, beaver ponds were larger and contained more coho fry than non-beaver pools; thus, beaver increased rearing habitat for coho during the late summer low flow. Beaver represent a low-cost tool deserving more consideration for stream rehabilitation projects.

Codes: multi reach quant instream

Leiner, S. 1995. Growth, mortality and production of brown and rainbow trout in New Mexico streams. Ribarstvo. Zagreb 53: 51-62.

Thirty-two representative trout sites in 15 high elevation New Mexico streams (1,661 - 2560 m above sea level) were sampled in 1988 and 1989. Fish (Salmo trutta, m. fario and Oncorhynchus mykiss) was captured by consecutive removal via electrofishing in net-blocked segments from 65 to 160 m long. Maximum estimated trout length (L sub(max)) was related inversely to yield. Instantaneous rate of mortality was also marginally related to yield. The production index ranged from 1.38 to 32.02 g/m super(2)/year. Variation in production was highly correlated to trout biomass. Trout growth and production were best defined by the relationships where: cover, stream width, water temperature, yield by anglers, L sub(max), and nitrate-nitrogen concentration were included.

Codes: multi quant popdyn instream watqual fishing

Leiner, S. 1996. The habitat quality index applied to New Mexico streams. Hydrobiologia 319: 237-249.

The accuracy of two trout biomass (standing stock) prediction models, developed for Wyoming streams by Binns & Eiserman (1979), was evaluated for New Mexico streams inhabited by brown trout, Salmo trutta L. and rainbow trout, Oncorhynchus mykiss Walbaum. Thirty-two representative sites in 15 different streams were sampled under summer low-flow conditions in 1988 and 1989. The 11 physical, chemical, and biological variables used in original models were used as independent variables for simple and multiple regression analysis designed to predict total trout biomass. Model I of Binns and Eiserman proved to be of limited utility; it explained 53% of the variation in total trout biomass at each of the New Mexico sites (kg/ha = 8.916 + 0.830/Model I/). Only 9.5% of the biomass variations was explained by Model II. Statistical analysis showed that trout biomass was significantly correlated with nitrate-nitrogen concentration and macroinvertebrate diversity in Model I. Because both variates are time consuming to estimate, Model I may not be any more cost-effective than sampling trout directly. The low predictive power of Model II probably indicates that it is limited to the geographical area of field measurement origin.

Codes: multi habitat quant instream warning watqual trophic

Leiner, S., and R. A. Cole. 1995. Habitat related models that predict rainbow and brown trout biomass in New Mexico streams. Ichthyos. Ljubljana 12: 13-41.

In contrast with other statistical models developed to predict trout biomass for management purposes, models developed during this study include fishing intensity and stocking variables, both of which are important management attributes that influence the relative contributions of other variables to management models. Thirty two sites on 15 high elevation streams were chosen to represent trout streams throughout state of New Mexico. Combined, brown (Salmo trutta) and rainbow (Oncorhynchus mykiss) trout biomass was simply correlated with nitrate-nitrogen concentration (r super(2) = 0.205; P = 0.009), zoobenthic biomass (r super(2) = 0.259; P = 0.003), and zoobenthic diversity (r super(2) = 0.472; P less than or equal to 0.001). Brown trout biomass was positively correlated with cover (r super(2) = 0.191; P = 0.012) and negatively correlated with fishing intensity (r super(2) = 0.152; P = 0.027). Rainbow trout biomass was positively correlated with zoobenthic biomass (r super(2) = 0.202; P = 0.010), zoobenthic diversity (r super(2) =0.588; P degree 0.001), nitrate-nitrogenconcentration (r super(2) = 0.135; P = 0.039) and nutrient (total nitrogen or total phosphorus) concentration (r super(2) = 0.125; P = 0.047). The model that explains the most variation (adjusted R super(2) = 0.831) of combined trout biomass included five physical, two chemical, one biological, and one angler-oriented attributes. More useful management models, which excluded the expensive biological variables, explained between 67 and 74 percent of trout biomass variation. The brown trout model that explained the greatest variation in biomass (R super(2) sub(a) = 0.779) included zoobenthos diversityand five other variables. More management efficient models excluded all biological variables and explained between 66 and 71 percent of brown trout biomass variation. The most explanatory model for rainbow trout biomass (R super(2) = 0.880) relied heavily on biological variables and no suitable management alternatives were found that did not include at least one biological variable.

Codes: multi reach quant instream wtaqual trophic fishing

Lek, S., A. Belaud, P. Baran, I. Dimopoulos, and M. Delacoste. 1996. Role of some environmental variables in trout abundance models using neural networks. Aquatic living resources/Ressources vivantes aquatiques. Nantes 9: 23-29.

Neural networks provide a "black box" model for explaining and predicting trout abundance with 8 environmental variables. This work investigates the specific effect of each variable, by inputting fictitious configurations of explanatory variables and by checking the responses of the model. The comparison between this response of the model to environmental variables on one hand, and results from field observations on the other hand, shows similarities and indicates neural network modelling can be trusted. The elevation appears to be the major explanatory factor. The influence of shelters, bottom velocity and Froude number also play an important role. When considered separately, depth does not have a notable influence on the density of trout. Such confirmations of field observations suggest that these models can be used to obtain a clear identification and hierarchization of the factors influencing the abundance of trout and the mode of action of the factors. This approach can be extended to other applications in quantitative ecology in which non-linear relationships are usually observed.

Codes: modeling habitat quant instream

Levings, C. D., and R. B. Lauzier. 1991. Extensive use of the Fraser River basin as winter habitat by juvenile chinook salmon (Oncorhynchus tshawytscha). Can. J. Zool./J. Can. Zool. 69: 1759-1767.

Habitat in the low-water channel of the mainstem Fraser River and larger tributaries during winter may be an unappreciated factor influencing production of stream-type chinook salmon (Oncorhynchus tshawytscha) in this system. Data from electrofishing surveys showed that shorelines were used by juvenile chinook from river km 110 to km 770. Almost the entire mainstem was therefore probably winter habitat, and major tributaries such as the Thompson, Quesnel, and Nechako rivers were also used. Estimated chinook density on the mainstem Fraser increased with distance upstream (maximum 0.30 m super(-2) at km 750 (Prince George)), but the highest density (0.99 m super(-2)) in the surveys was observed on the Thompson River at Spences Bridge. The mean size of juvenile chinook decreased with distance upstream on the Fraser, ranging from 97 mm at km 110 to 65 mm at km 770. Chinook juveniles were feeding on Diptera, Trichoptera, and Plecoptera in winter. Some apparent growth was observed in the lower Fraser in early winter.

Codes: reach quant instream

Levings, C. D., and D. J. H. Nishimura. 1997. Created and restored marshes in the Lower Fraser River, British Columbia: Summary of their functioning as fish habitat.

Ecological comparisons of transplanted, natural (reference) and disrupted(unvegetated) marsh sites on the Fraser River estuary, British Columbia, were conducted between 1991 and 1994. The study examined vegetative biomass and cover, invertebrate abundance, fish abundance, fish residency, fish food, and submergence time for the three habitats. Standing crop biomass at 3 transplanted sites were within the range of values for reference sites but was much lower at an unstable site where sediment slumping had occurred. In all study reaches, abundance of invertebrates at transplant and reference sites was significantly higher than at disrupted sites. No significant difference was observed among marsh sites when chum salmon (Oncorhynchus keta) and chinook salmon (O. tschawytscha) fry abundance were compared. However, chinook and sockeyesalmon (O. nerka) smolt catches were significantly different among marsh sites and were usually higher at disrupted sites. The study shows that numerous factors need to be examined in determining if restored marshes will function as natural habitats. The development of a standardized set of reference criteria would assist in invaluating whether or not transplanted marshes are functioning as designed.

Codes: experi reach offchann trophic instream

Li, H. W., G. A. Lamberti, T. N. Pearsons, C. K. Tait, J. L. Li, and J. C. Buckhouse. 1994. Cumulative effects of riparian disturbances along high desert trout streams of the John Day Basin, Oregon. TAFS 123: 627-640.

In a study of cumulative effects of riparian disturbance by grazing on the trophic structure of high desert trout streams, watersheds with greater riparian canopy had higher standing crops of rainbow trout Oncorhynchus mykiss, lower daily maximum temperatures (range, 16-23 degree C compared with 26-31 degree C), and perennial flow. Watershed aspect influenced the response of trophic structure to grazing influences. Standing corps of rainbow trout were negatively correlated with solar radiation and maximum temperature in watersheds flowing northward. A different relationship was observed for a set of watersheds with a southern aspect, perhaps due to the presence of spring seeps and stream desiccation in the heavily grazed stream. Trout biomass was negatively correlated with solar radiation, whereas positive relationships were found for discharge and depth. Algal biomass was positively correlated with solar insolation ($r = 0.91$), total invertebrate biomass ($r = 0.77$), and herbivorous invertebrate biomass ($r = 0.79$) in all watersheds. Invertebrate biomass was not significantly correlated with rainbow trout standing crop. High irradiance apparently resulted in increased algal biomass and invertebrate abundance. However, temperature elevations to levels close to lethal may impose high metabolic costs on rainbow trout, which may offset higher food availability and affect the availability of prey.

Codes: reach multi graz ripar wtemp trophic quant

Li, H. W., C. B. Schreck, C. E. Bond, and E. Rexstad. 1987. Factors influencing changes in fish assemblages of Pacific Northwest streams. Pages 193-202. In Community and evolutionary ecology of North American stream fishes. W. J. Matthews and D. C. Heins, editors. University of Oklahoma Press, Norman, OK.

Recent structural alterations to watersheds of the Pacific Northwest have changed the ecological setting for fish assemblages. Dams have acted as physical zoogeographic barriers and may have increased the importance of fish diseases both of zoogeographic barriers and as mechanisms structuring fish assemblages. The impoundments favor the establishment of exotic, temperate mesotherms and eurytherms from the Midwest. Forestry, grazing, and bank-stabilization practices have changed the morphology of watersheds and diminished the role of large woody debris and riparian vegetation. Fishing has depleted juvenile Oncorhynchus tshawystscha, and certain other species no longer support commercial fisheries. Harvesting of salmonids has led to a significant reduction of nutrient input to nutrient-poor stream complexes. Stock depletion has given rise to hatcheries that now produce fish that are different genetically from the ancestral populations.

Codes: multi reach qual graz ripar

Lim, P., G. Segura, A. Belaud, and C. Sabaton. 1993. Study of the habitat of brown trout (Salmo trutta fario). Role of artificial and natural covers on trout populations. Edited by J. P. Grandmottet, J. P. Masson, G. Balvay and J. Verneaux. 373-396 p.

The aim of this study was to quantify the role of various cover types and examine their selection by brown trout. The study was developed on two river course sections in the Pyrenees: the river PIQUE (altitude 920 m NGF) and the river GER (altitude 390 m NGF), situated in the department of the Haute-Garonne (31). For the natural cover, we have experimented on three sets which have been transitionally blocked by wire netting; rocky river bank, undercut bank and woody debris. This has been performed on the river GER. Initially, the sector, for all these types of covers, had an average density of 2469 ind/ha for a biomass of 278 kg/ha. When the access to the covers is protected, the density stabilises to 1000 ind/ha, being a decrease in the order of 55% in density and biomass. According to the type of cover, the recolonisation, after 21 days of reopening of the covers, is estimated between 28 and 72% for the biomass and between 42 and 62% for the density. For the artificial covers, six types of building materials (brick, tile ...) have been experimented on the river PIQUE section (all natural covers having been removed). By type of covers and their location, the trout density varied from 3 to 23 ind/m super(2) of cover, and from 0.09 to 0.2 ind/m super(2) outside cover. Among the material used, we observed a clear preference for brick and, depending on the dispositions tested, the best results have been obtained with the covers placed near the banks, or being in the totality of the bed. The experiment has shown the major role the natural and artificial covers have on trout populations.

Codes: experi microhab quant instream

Linlokken, A. 1997. Effects of instream habitat enhancement on fish populations of a small Norwegian stream.

Weirs and pools were created by using an excavator on a 200 m long experimental section in a small tributary (mean discharge 0.95 m super(3)/s) of the River Glomma in southeastern Norway. The experimental section was once dredged to facilitate timber floating. The most abundant fish species in the stream were brown trout (Salmo trutta), bullheads (Cottus poecilopus) and minnows (Phoxinus phoxinus). Four weirs, placed in two pairs, were constructed to create 10 m wide, 15 m long and approximately 1.5 m deep pools. Small pools, 2-3 m wide and 0.7 m deep, were distributed in the stream bed between the two pairs of weirs. The density of brown trout was annually estimated by means of the mark-recapture method for the first two years (1986-87) and by successive removal the last year before enhancement (1988) and annually during six years after the enhancement (1989-96, except in 1993-94). A reference section was sampled simultaneously, except in 1989. The mean density of brown trout on the experimental section was 18.3 per 100 m prior to enhancement, and increased by 200% after the construction of weirs. The increase was due to increased number of specimens > 10 cm, whereas number of specimens <10 cm (agegroups less than or equal to 1+) decreased. In 1996 the density was reduced close to the conditions before enhancement, and this was probably caused by a heavy flood in 1995, deteriorating the weirs followed by a cold winter with thin snow layer and a thick ice cover. Age group 2+ dominated in the pooled sample, and low representation of agegroups less than or equal to 1 + indicated that the brown trout stock on this section must be recruited by immigration from sections upstream.

Codes: experi quant migrat instream temporal

Lisle, T. E. 1986. Effects of woody debris on anadromous salmonid habitat, Prince of Wales Island, southeast Alaska. North American Journal of Fisheries Management 6: 538-550.

The effects of woody debris on anadromous salmonid habitat in eight streams on Prince of Wales Island, southeast Alaska, were investigated by comparing low-gradient (1-9%) first- or second-order streams flowing through either spruce-hemlock forests or 6-10 year-old clear-cuts, and by observing changes after debris was selectively removed from clear-cut reaches. Woody debris decreased the rate of shallowing as discharge decreased, thus helping to preserve living space for fish during critical low-flow periods. Debris dams were more frequent in clear-cut streams (14.9/100 m), which contained more debris, than in forested streams (4.2/100 m). As a result, total residual pool length (length when pools are filled with water but there is no flow) and length of channel with residual depth greater than 14 cm--the depth range occupied by 84% of coho salmon (Oncorhynchus kisutch)--were greater in clear-cut streams than in forested streams. Greater volumes of woody debris in clear-cut streams produced greater storage of fine sediment (<4-mm diameter) unless the stream gradient was sufficiently high to flush sediment from storage. One-half of the debris dams broke up or were newly formed over a 3-year period, which suggests that they usually released sediment and woody debris before the pools they formed were filled with sediment. Woody debris removal decreased debris-covered area, debris dam frequency, and hydraulic friction in some cases but, in others, these variables were unaffected or recovered within 2 years after erosion and adjustment of the streambed. No consistent differences in pool dimensions were found between treated and untreated clear-cut reaches. Comparisons of habitat in forested and clear-cut streams suggested that removing debris from clear-cut streams reduced salmonid carrying capacity. Retention and natural reformation of debris dams in cleared reaches prevented the expected deterioration of habitat. However, the removal and destabilization of existing woody debris may cause depletion of debris before riparian trees can regrow and furnish new material to the clear-cut streams.

Codes: multi nofish ripar instream substrate lwd

Loar, J. M. 1985. Application of habitat evaluation models in southern Appalachian trout streams. Final project report. Report ORNL/TM-9323.

Habitat evaluation models are being widely used to identify instream flow requirements for aquatic biota at hydroelectric projects and other water resource developments. A study was conducted to evaluate the validity of physical habitat indices for predicting the response of trout (Salmo gairdneri) populations to changes in stream-flow. Because the use of habitat indices is based on the assumption that fish abundance or biomass is positively correlated with the value of the habitat index, the study focused on an analysis of fish-to-habitat relationships. Eight study sites on cold water streams with naturally reproducing populations of brown and rainbow trout were selected. Fish biomass, abundance, and production were estimated, using electrofishing and Petersen mark-recapture techniques. Physical habitat was quantified, using the IFIM's Physical Habitat Simulation (PHABSIM) system at each site. Habitat condition alone was not sufficient to explain differences in rainbow trout abundance. (Environ. Sci. Div. No. 2383.).

Codes: reach quant microhab instream ifim warning hem

Lobon-Cervia, J. 1996. Response of a stream fish assemblage to a severe spate in northern Spain. Transactions of the American Fisheries Society 125: 913-919.

I assessed the effects of a devastating spate upon the populations of brown trout Salmo trutta, Atlantic salmon S. salar, and European eel Anguilla anguilla of the Esva River basin in northern Spain. Numbers and lengths were determined for fish sampled with electrofishing techniques at nine sites along three streams before and after the spate. In addition, brown trout and Atlantic salmon that had been marked in two streams prior to the spate permitted a direct evaluation of the immediate effects. Because the spate occurred at the spawning time and destroyed reproductive habitats, I also determined its effects upon the recruitment of that year-class of brown trout. There was no evidence of negative effects of the spate upon the variables examined. The persistence of the site-specific populations after the spate was independent of site characteristics and the corresponding numbers and sizes of fish. The recruitment of brown trout was successful and similar to that of previous years. I hypothesize that mechanical responses related to microhabitat use permit brown trout and Atlantic salmon to withstand spates.

Codes: experi reach quant hydro noenv

Lonzarich, D. 1992. Patterns of community structure and microhabitat use by stream fishes in three Washington streams. Northwest Science 66: 137.

Studies on the ecology of streams in the Pacific Northwest focus almost exclusively upon salmonids and have consequently biased our views of how these systems function and respond to land-use disturbances. An approach is advanced here that integrates information on the biology of other stream fishes with knowledge of salmonids to better evaluate the impacts of stream disturbance. Comparisons are made of fish assemblages in different streams examining relationships with habitat structure and flow regime. Further, potential inter-relationships among species are examined through studies of habitat and microhabitat use. Seasonal electro-shocking and snorkeling surveys were conducted three Washington streams from summer 1990 to the present.

Codes: multi reach quant sppinter instream hydro

Lorenz, J. M., and J. H. Eiler. 1989. Spawning habitat and redd characteristics of sockeye salmon in the Glacial Taku River, British Columbia and Alaska. Transactions of the American Fisheries Society 118: 495-502.

Spawning habitats of sockeye salmon Oncorhynchus nerka in the Taku River and its tributaries in British Columbia and Alaska were studied to determine habitat use and redd characteristics in a glacial river system. We used radiotelemetry to track adult sockeye salmon to 26 spawning reaches, and 63 spawning sites were sampled for habitat characteristics. Over 40% of the sockeye salmon in the sampling area had a freshwater age of zero, and most of these spawned in main channels or off-channel areas. The availability of upwelling groundwater influenced habitat use in the main stem of the river; upwelling groundwater was detected in nearly 60% of the sites sampled in main-stem areas. Spawning sites with upwelling groundwater had lower water velocities and more variable substrate compositions than sites without upwelling groundwater.

Codes: multi reach qual spawn migrat instream hydro

Maeki-Petaeys, A., T. Muotka, and A. Huusko. 1999. Densities of juvenile brown trout (Salmo trutta) in two subarctic rivers: Assessing the predictive capability of habitat preference indices. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 56: 1420-1427.

The applicability was examined of habitat preference indices for predicting density variations of age-0 brown trout (Salmo trutta) in two rivers in northern Finland. Trout densities in these rivers were monitored for 7 or 8 years. Habitat suitability for trout fry was assessed using summer and winter preference curves for water velocity, depth, and substrate. Substrate suitability indices based on summer preference curves explained 21-74% of the among-site variation in trout densities. The negative effect of high discharge on trout abundance was best predicted by the composite depth x substrate index. Sites with the highest apparent survival (density of age-1 trout in year t versus density of age-0 trout in year t - 1) produced high indices when winter substrate curves for age-0 trout were used, indicating high immigration rates to these sites. This study shows that when preference indices are used for predictive purposes, the mechanisms underlying habitat bottlenecks must be known. In boreal areas, winter presents a bottleneck period forjuvenile salmonids, and the importance is stressed of using winter habitat curves when habitat hydraulic models are applied to areas with severe winter conditions.

Codes: multi reach microhab quant popdyn instream substrate warning hem

Manske, M., and C. J. Schwarz. 2000. Estimates of stream residence time and escapement based on capture-recapture data. Canadian Journal of Fisheries and Aquatic Sciences 57: 241-246.

The area-under-the-curve method is a widely used method for estimating salmon escapement. The method depends on obtaining an accurate estimate of stream residence time, or stream life. This paper develops an estimator of stream residence time based oncapture-recapture data. If the capture-recapture experiment is performed on the entire population, the escapement can also be estimated using the area-under-the-curve method. Simulations showed that the stream residence estimator and the area-under-the-curve estimator provide precise estimates of stream residence and escapement, respectively. These methods were used to estimate the stream residence times and escapements of coho salmon (Oncorhynchus kisutch) in a small river on Vancouver Island in 1989 and 1990.

Codes: method quant migrat

Marchand, F., and D. Boisclair. 1998. Influence of fish density on the energy allocation pattern of juvenile brook trout (Salvelinus fontinalis). CJFAS 55: 796-805.

The objectives of this study were 1) to assess the influence of fish density on the energy allocation pattern of juvenile brook trout (Salvelinus fontinalis) and 2) to define the mechanism by which this influence occurs. Growth, consumption, and activity rates were estimated of brook trout held in 8-m super(3) enclosures characterized by two different densities (four or eight fish per enclosure; D4 and D8 enclosures, respectively). Eight experiments designed to estimate these variables were performed during a 27-day period. Fish from D4 enclosures grew twice as much as those from D8 enclosures. For any given experiment, consumption rates were not significantly different between the two fish densities (0.434-1.09 g dry - 100 g wet super(-1) times day super(-1)). Fish stocked in D8 enclosures displayed more agressive behavior, executed 5.5 times more movements, and swam at speeds 13% faster than fish in D4 enclosures. These differences resulted in activity rates fourfold higher in D8 enclosures than in D4 enclosures. Empirical analyses combining results with published values of growth, consumption, and activity rates supported the hypothesis that competition can have a negative effect on growth through a decrease in consumption rates and an increase in activity costs.

Codes: experi enclos quant popdyn trophic

Marschall, E. A., and L. B. Crowder. 1996. Assessing population responses to multiple anthropogenic effects: a case study with brook trout. Ecological Applications 6: 152-167.

Population declines are often caused by multiple factors, including anthropogenic ones that can be mitigated or reversed to enhance population recovery. We used a size-classified matrix population model to examine multiple anthropogenic effects on a population and determine which factors are most (or least) important to population dynamics. We modeled brook trout (Salvelinus fontinalis) in southern Appalachian mountain streams responding to multiple anthropogenic effects including the introduction of an exotic salmonid species (rainbow trout, Oncorhynchus mykiss), a decrease in pH (through acidic deposition), an increase in siltation (from roadbuilding and logging), and an increase in fishing pressure. Potential brook trout responses to rainbow trout include a decrease in survival rate of small fish, a change in density dependence in survival of small fish, and a decrease in growth rates of all sizes. When we included these responses in the population model, we found that population size tended to decrease with an increase in small-fish growth rate (producing a population with fewer, but larger, fish). In addition, changes in patterns of density-dependent survival also had a strong impact on both population size and size structure. Brook trout respond to decreases in pH with decreased growth rate in all size classes, decreased survival rates of small fish, and decreased egg-to-larva survival rates. This combination of effects, at magnitudes documented in laboratory experiments, had severe negative impacts on the modeled population. If siltation effects were severe, the extreme increase in egg-to-larva mortality could have strong negative effects on the population. However, even very strong increases in large fish mortality associated with sport harvesting were not likely to cause a local extinction. In all of these cases, the interaction of drastic changes in population size structure with randomly occurring floods or droughts may lead to even stronger negative impacts than those predicted from the deterministic model. Because these fish can reproduce at a small size, negative impacts on survival of the largest fish were not detrimental to the persistence of the population. Because survival of small juveniles is density dependent, even moderate decreases in survival in this stage had little effect on the ultimate population size. In general, a brook trout population will respond most negatively to factors that decrease survival of large juveniles and small adults, and growth rates of small juveniles.

Codes: modeling popdyn substrate

Marshall, D. E., and E. W. Britton. 1990. Carrying capacity of coho salmon streams. CAN. MANUSCR. REP. FISH. AQUAT. SCI. 2058: 38.

The carrying capacity of coho (Oncorhynchus kisutch) salmon streams was analyzed by comparing coho smolt yields (expressed as numbers and biomass) with rearing space (expressed as length and area of stream accessible to spawners). The two smolt yield variables and the two rearing space variables were analyzed for a linear relationship using the equation y = a + bx, and for a curvilinear relationship using the equation y = ax super(b). The goodness of fit (r) of data points to the two regression types was then compared. The data were obtained from the literature and unpublished sources, and included one or more years of smolt output data, and data on length and/or area for 21 streams, 2 ponds and 2 side channels.

Codes: multi reach quant spawn noenv

Martin, D. J., L. J. Wasserman, and V. H. Dale. 1986. Influence of riparian vegetation on posteruption survival of coho salmon fingerlings on the west-side streams of Mount St. Helens, Washington. North American Journal of Fisheries Management 6: 1-8.

The 1980 eruption of Mount St. Helens impacted salmon streams on the west side of the mountain primarily by debris and mud deposits; depositions of ash and large wood were relatively minor disturbances. We examined factors related to juvenile coho salmon (Oncorhynchus kisutch) disappearance during the summer and winter months of 1981 and 1982. Correlations exist between the survival of anadromous fish, instream vegetative debris cover, and water temperature. Summer mortality was related to high stream temperatures and winter mortality to the lack of large organic debris. Recovery of riparian vegetation would reduce stream temperatures and cause debris to be retained. Tree growth data suggest trees will be tall enough to effectively shade the third- and fourth-order streams in 5-20 years, and that it will be 50-75 years before the trees are large enough to create organic debris structures when they fall into a stream. These results imply that management activities that promote large organic debris will enhance fish survival.

Codes: experi multi reach qual ripar substrate

Martin, D. J., L. J. Wasserman, R. P. Jones, and E. O. Salo. 1984. Effects of Mount St. Helens eruption on salmon populations and habitat in the Toutle River. Report FRI-UW-8412. experi reach popdyn instream lwd substrate.

The eruption of Mount St. Helens on May 18, 1980 caused massive devastation of fishery resources in the Toutle River watershed. Catastrophic changes caused by the debris avalanche, pyroclastic flows and mudflows destroyed fish populations and 218 km (77 percent) of the 280 km of anadromous fish habitat formerly utilized by salmonids. Adult salmon spawned in unstable volcanic substrates with average concentrations of fine particles ranging from 11.2 percent to 36.0 percent in 1981 and from 11.2 percent to 33.5 percent in 1982. Survival of eggs to hatching stage in volcanic substrate ranged from 50 percent to 95 percent. Any success was attributed to groundwater upwelling. Juvenile coho mortality ranged from 0 percent to 83 percent during the summer period and was closely associated with high water temperature. Mortality during winter ranged from 62-83 percent in unaffected streams and 82-100 percent in affected streams and was associated with channel stability, suspended sediment, and the amount of cover provided by large organic debris.

Codes: experi reach popdyn instream lwd substrate

Mather, M. E. 1998. The role of context-specific predation in understanding patterns exhibited by anadromous salmon. Canadian Journal of Fisheries and Aquatic Sciences 55: 232-246.

Predation is frequently studied in aquatic systems that contain salmon. Because these systems are difficult to manipulate and replicate, rigorous across-system comparisons are essential. Herein I review the literature on factors that may influence predation across systems. Specifically, I evaluated how often predation on salmonids was important across prey taxa, life stage, habitat, predator taxa, methodology, and spatial scale. Further, I examined what factors were influential in systems where predation was important. In nine journals from 1959-1996, 45 field studies explicitly tested the importance of direct effects of predation on anadromous salmonid prey. Authors of 36 (80%) studies concluded that predation was important. More studies in which predation was deemed important focused on smolts subjected to fish predation in the transitional river and estuary habitats. Furthermore, field surveys at larger spatial scales were most often used. Finally, most studies reported little information on confounding factors that complicate predation. If we are to learn from these complex systems, we need to collect, analyze, and report similar types of information that are collected across systems and years using rigorous and systematic methods.

Codes: review habitat reach sppinter warning

Matthews, K. R., N. H. Berg, D. L. Azuma, and T. R. Lambert. 1994. Cool water formation and trout habitat use in a deep pool in the Sierra Nevada, California. Transactions of the American Fisheries Society 123: 549-564.

The authors documented temperature stratification in a deep bedrock pool in the North Fork of the American River, described the diel movement of rainbow trout Oncorhynchus mykiss and brown trout Salmo trutta, and determined whether these trout used cooler portions of the pool. From July 30 to October 10, 1992, the main study pool and an adjacent pool were stratified (temperature differences between surface and bottom were as great as 4.5 degree C) on all but two days. Six rainbow and one brown trout equipped with temperature-sensitive radio transmitters used water with temperatures ranging from 12 to 19.3 degree C. During the late afternoon, when the widest range of water temperature was available, trout were found in temperatures up to 19.3 degree C even though cooler (14.5

degree C) water was available. Radio tracking indicated that fish were significantly more active and had significantly larger home ranges at night; fish were least active during the day. Because we found no evidence of subsurface seepage into the pool and water flowing into the pool was warmer than the pool's maximum temperature, we concluded that the geometry and depth of deep pools may moderate elevated summer water temperatures that can stress trout populations.

Codes: habitat microhab qual instream wtemp

May, C. W., E. B. Welch, R. R. Horner, J. R. Karr, and B. W. Mar. 1997. Quality Indices for Urbanization Effects in Puget Sound Lowland Streams.

The Puget Sound lowland (PSL) ecoregion contains an abundance of complex and historically productive salmonid habitat in the form of small streams as well as their riparian forests and wetlands. These watersheds are under intense pressure due primarily to the cumulative effects of urban development. Instream habitat characteristics, riparian conditions, physio- chemical water-quality, and biological attributes of 22 PSL streams (120 survey reaches) were studied over a gradient of development levels to determine relationships between urbanization and stream quality and suggest target conditions for management/protection. Urbanization of PSL watersheds has resulted in an increase in the fraction of total impervious area (% TIA) and a decrease in forested area, including a significant loss of natural riparian forests and wetlands. The cumulative effects of a modified hydrologic (distrubance) regime, the loss of instream structural complexity, and the alteration of channel morphological characteristics accompanying urbanization have resulted in substantial degradation of instream habitat during the initial phases of the development process.

Codes: multi reach nofish ripar instream

McMahon, T. E., and L. B. Holtby. 1992. Behaviour, habitat use, and movements of coho salmon (Oncorhynchus kisutch) smolts during seaward migration. Canadian Journal of Fisheries and Aquatic Sciences 49: 1478-1485.

Coho salmon (Oncorhynchus kisutch) smolts formed aggregations in pools with large woody debris during their migration downstream and into the Carnation Creek estuary, British Columbia. Smolts utilized the estuary throughout the smolt run, with periods of high outmigration coinciding with spring tides which brought warmer, more saline water into the estuary. Smolt abundance in the stream and estuary was positively related to debris volume, and 82% of the 1260 smolts observed during underwater counts occurred within 1 m of debris. Debris volume and smolt density were significantly lower in clearcut than in buffered stream sections. Our observations support the need to retain and manage large woody debris for smolt habitat in streams and estuaries.

Codes: reach quant migrat lwd ripar

McMenemy, J. R. 1995. Survival of Atlantic salmon fry stocked at low density in the West River, Vermont. North Am. J. Fish. Manage. 15: 366-374.

Fry of Atlantic salmon Salmo salar stocked at low density (32/100 m super(2); plus or minus 0.7, SE) in the West River, Vermont, produced underyearling and yearling parr densities of 13.5 plus or minus 0.8/100 m super(2) and 5.9 plus or minus 0.5/100 m super(2), respectively. Survival of fry stocked at low density to underyearling and yearling parr was 42 plus or minus 2.5% and 19 plus or minus 1.3%, respectively. Density of underyearling parr produced from fry stocked at low density was not significantly different from the 10.6 plus or minus 1.5 parr produced from fry stocking at high density (mean, 117 plus or minus 16.5/100 m super(2)). However, the 4.0 plus or minus 0.8 yearling parr/100 m super(2) produced was significantly lower at high stocking density. Survival to underyearling and yearling parr at high stocking density was 11.6 plus or minus 2.0% and 4.6 plus or minus 1.0%, respectively, both significantly lower than survival rates at low stocking density. Thus, low-density stocking produced equal or greater densities of parr with much higher survival rates. Estimated smolt production from low-density fry stocking (with the assumption of a parr-to-smolt overwinter survival rate of 65%) was about 4.0 smolts/100 m super(2); this is equivalent to a fry-to-smolt survival rate of 13%. Results from stocking fed and unfed fry were similar, except fed fry were more likely to produce yearling smolts. Managers of restoration and enhancement programs with limited broodstock, eggs, or incubation space should be able to produce more smolts by stocking fry at lower densities over wider areas without affecting per-unit-area smolt production.

Codes: experi reach quant popdyn noenv

McMichael, G. A., and T. N. Pearsons. 1998. Effects of wild juvenile spring chinook salmon on growth and abundance of wild rainbow trout. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 127: 261-274.

We investigated some of the ecological impacts to rainbow trout Oncorhynchus mykiss that could occur by supplementing spring chinook salmon O. tshawytscha in the upper Yakima River basin, Washington. Controlled field experiments conducted in three different streams indicated that presence of wild juvenile spring chinook salmon did not adversely affect growth of wild rainbow trout in high-elevation tributaries. Experiments at two spatial scales, habitat subunit and stream reach scales, were used to detect impacts. Insmall-enclosure experiments conducted in two tributaries to the Yakima River in 1993 and 1994, specific growth rates (SGRs) of wild rainbow trout paired with wild juvenile spring chinook salmon were not significantly lower than SGRs of their unpaired counterparts (1993: $P = 0.360$; 1994: $P = 0.190$). Stream reach experiments in another Yakima River tributary in 1995 also indicated that introductions of wild juvenile spring chinook salmon into 100-m-long enclosures, at a numerical density equal to the preexisting wild rainbow trout, did not adversely affect rainbow trout growth or abundance. The mean fork length (FL) and instantaneous growth rate (IGR) of age-O wild rainbow trout in stream reach enclosures were unaffected by introduced spring chinook salmon after 7 (FL: $P = 0.318$) and 14 weeks (FL: $P = 0.387$, IGR: $P = 0.265$) in sympatry. Mean fork lengths and IGRs of age-1 rainbow trout were also unaffected by the addition of the spring chinook salmon after 7 weeks (FL: $P = 0.553$, IGR: $P = 0.124$) and 14 weeks (FL: $P = 0.850$, IGR: $P = 0.084$) of cohabitation. Furthermore, the stream reach experiment showed that spring chinook salmon introduction did not affect rainbow trout abundance ($P = 0.298$) or biomass ($P = 0.538$). Site elevation in the stream reach tests appeared to influence rainbow trout size more than the addition of juvenile spring chinook salmon. Site elevation was negatively correlated with length of wild age-O ($P < 0.001$) and age-1 ($P < 0.001$) rainbow trout in October 1995. It appears that rainbow trout and spring chinook salmon partitioned the resources so that impacts were not detected. Our work suggests that rainbow trout have a refuge from interactions with juvenile spring chinook salmon in high-elevation portions of tributaries (e.g., over 700 m).

Codes: experi multi habitat enclos reach quant popdyn sppinter

MDFG. 0. The effect of cattle grazing on brown trout in Rock Creek, Montana. Montana Department of Fish and Game Special Report

Studies of a natural, free-flowing stream section with densely vegetated banks showed better fish population structure than a contiguous section flowing through a heavily grazed area. The natural area supported 4,645 brown trout per hectare at 238.8 kilograms per hectare compared to 1,732 browns at 71.0 kg/ha n the overgrazed area. Thus, the biomass of brown trout was 3.4 times greater in the natural area. Species other than brown trout were 20% more numerous in the grazed area. Large numbers of juvenile mountain whitefish accounted for the difference. The natural area possessed fewer numbers of other fish, but they exceeded the biomass of the grazed area by 87%. The ungrazed section had 82% more cover per hectare of stream than the grazed section. Marked differences in floristic composition and density of herbaceous vegetation was evident between the two areas. Overgrazing and subsequent stream course alteration had essentially eliminated tall and low shrub strata. The combination of too many cattle, reduced vegetation and poor soils led to 80% more stream channel alteration in the grazed area. In addition, the stream channel was wider, shallower and continually migrated within the grazed area.

Codes: reach experi graz quant

Mesick, C. F. 1995. Response of brown trout to streamflow, temperature, and habitat restoration in a degraded stream. Rivers 5: 75-95.

In Rush Creek, California, historical dewatering, flooding, grazing, and gravel operations reduced the quantity of gravel, woody debris, and pool habitat; widened and incised the channel in the downstream reaches; and restricted the riparian vegetation to a narrow band along the stream margin. This study monitored the self-reproducing brown trout (Salmo trutta) population in degraded and undisturbed reaches from 1985 to 1993, primarily to determine the response to streamflow and restoration work. High streamflow in conjunction with fluctuating temperatures during winter reduced survival of juvenile trout and growth rates of all ages. Maximum summer water temperatures were also negatively correlated with growth and survival rates. Moderate summer streamflows reduced temperature fluctuations, particularly in the downstream segments, thereby improving growth and survival; however high summer flows reduced growth rates and eliminated large prey. The availability of large prey resulted in high growth and survival in spite of high summer temperatures. Survival and growth were positively correlated with the amount of pool habitat, water depth, and streambed complexity, particularly when winter flows and summer water temperatures were high. Gravel availability and young-of-the-year production increased with high flows prior to spawning. However, moderate flows mobilized instream gravel without providing gravel recruitment. Gravel added to the stream as part of restoration work increased young-of-the-year densities, particularly in the reaches where gravel was placed. Large pools excavated in the main channel that had root wads and clusters of boulders added for cover increased growth rates but did not increase survival when winter flows were high. Rewatered side channels, some with excavated pools, were utilized by few trout but increased survival and growth when winter flows were high.

Codes: reach exper graz ripar instream hydro quant popdyn

Metcalfe, N. B., N. H. C. Fraser, and M. D. Burns. 1999. Food availability and the nocturnal vs. diurnal foraging trade-off in juvenile salmon. Journal of Animal Ecology 68: 371-381.

Much attention has been devoted to explaining the spatial distribution of foraging animals, but rather little to their temporal distribution (i.e. whether they are diurnal, nocturnal or crepuscular). Many animals face predictable diel cycles of food availability or predation risk, and so the approach of measuring the relative ratio of mortality risk to food gained (the `minimize mu /f rule) can be applied equally as well to different time periods of the day as to alternative food patches or habitats. 2. This method is used here to investigate the diel activity patterns of juvenile Atlantic salmon, which have previously been shown to become increasingly biased towards nocturnal activity in winter, hiding for much of the day in streambed refuges. Calculations based on published data show that nocturnal foraging in winter is far safer per unit of food obtained than is diurnal, despite greatly reduced food capture efficiency at night-time light levels. 3. Using an automated activity monitoring system based on passive integrated transponder (PIT) tags, this study shows that winter diel activity patterns in salmon are dependent on food availability. A change in food density led to a parallel change in time spent in the refuge, but (as predicted by the mu /f rule) the effect was greatest at the time of day with the least favourable ratio of predation cost to feeding benefit. Thus an experimental increase in food availability led to a 16% reduction in time spent in nocturnal foraging but a 98% reduction in time spent foraging by day, with fish spending only 0 times 6% of the daylight hours out of the refuge at the highest food density. 4. However, brief daytime foraging bouts had a major impact on growth rates (presumably because feeding efficiency was much greater in daylight), especially when food was scarce. Daytime feeding was thus profitable in terms of rapid food acquisition but normally suboptimal in terms of risk of predation. 5. Daily activity patterns are therefore suggested to be the result of a complex tradeoff between growth and survival, which takes account of diel fluctuations in food availability, food capture efficiency and predation risk; individual variation in the extent of diurnal feeding in salmon may result from state-dependent differences in the benefits of rapid feeding and growth.

Codes: experi habitat quant popdyn trophic instream

Meyer, K. A., and J. S. Griffith. 1997. Effects of cobble-boulder substrate configuration on winter residency of juvenile rainbow trout. North American Journal of Fisheries Management 17: 77-84.

We assessed first winter habitat use by placing wild rainbow trout Oncorhynchus mykiss (52-155 mm total length) in wire-mesh enclosures with different cover treatments and at varying fish densities. Cobble-boulder substrates (20-40 cm diameter) were arranged in four different configurations: (1) no cobble-boulders, (2) cobble-boulders present but not touching, (3) cobble-boulders touching in a single layer, and (4) cobble-boulders touching and stacked in two layers. As the configuration of rock substrate was changed to create more concealment cover, the number of fish remaining in the enclosures after 96 h increased significantly, even though the quantity of rock substrate did not change. The initial stocking density of fish had no overall significant effect on the number of fish remaining in enclosures after 96 h. However, analysis of each cover x density treatment showed that when the substrate arrangement created little concealment cover, the number of fish remaining in the enclosures did not increase with an increase in initial fish density, but when the substrate arrangement created relatively more concealment cover, more fish remained in the enclosures when the initial fish density was increased. In trials with rock cover present, fish emigrating from the enclosures were larger than those remaining in the enclosures. Our results demonstrate the importance of the configuration of cobble-boulder substrate in determining its suitability as winter cover for rainbow trout.

Codes: experi enclose habitat quant substrate

Milner, A. M., E. E. Knudsen, C. Soiseth, A. L. Robertson, D. Schell, I. T. Phillips, and K. Magnusson. 2000. Colonization and development of stream communities across a 200-year gradient in Glacier Bay National Park, Alaska, U.S.A. CJFAS 57: 2319-2335.

In May 1997, physical and biological variables were studied in 16 streams of different ages and contrasting stages of development following glacial recession in Glacier Bay National Park, southeast Alaska. The number of microcrustacean and macroinvertebate taxa and juvenile fish abundance and diversity were significantly greater in older streams. Microcrustacean diversity was related to the amount of instream wood and percent pool habitat, while the number of macroinvertebrate taxa was related to bed stability, amount of instream wood, and percent pool habitat. The percent contribution of Ephemeroptera to stream benthic communities increased significantly with stream age and the amount of coarse benthic organic matter. Juvenile Dolly Varden (Salvelinus malma) were dominant in the younger streams, but juvenile coho salmon (Oncorhynchus kisutch) abundance was greater in older streams associated with increased pool habitat. Upstream lakes significantly influenced channel stability, percent Chironomidae, total macroinvertebrate and meiofaunal abundance, and percent fish cover. Stable isotope analyses indicated nitrogen enrichment from marine sources in macroinvertebrates and juvenile fish in older streams with established salmon runs. The findings are encapsulated in a conceptual summary of stream development that proposes stream assemblages to be determined by direct interactions with the terrestrial, marine, and lake ecosystems.

Codes: multi reach temporal qual lakehydro trophic instream lwd

Milner, N. J., R. J. Hemsworth, and B. E. Jones. 1985. Habitat evaluation as a fisheries management tool. Journal of Fish Biology 27 (suppl. A): 85-108.

The application, rationale and process of habitat evaluation methods are discussed in the context of present day fisheries management. The need to consider habitat features at site and catchment level is stressed. Development of habitat evaluation techniques for assessing brown trout (Salmo trutta) habitat in Welsh streams is reported, and examples of these approaches are given: qualitative (visual assessment), semi-quantitative (a combination of subjective and quantitative measurements) and quantitative measurements on transect system). Habitat attribute-fish population models were based on functional linear regressions and multiple regression (for the quantitative method). The problems associated with soft-water sites are discussed in terms of factors affecting site carrying capacity.

Codes: philosophy qual quant microhab instream hem

Milner, N. J., R. J. Wyatt, S. Barnard, and M. D. Scott. 1995. Variance structuring in stream salmonid populations, effects of geographical scale and implications for habitat models. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 387-398 p.

Trout (Salmo trutta, L.) and salmon (Salmo salar, L.) populations in streams exhibit temporal and spatial variation. However, the ability of habitat models (empirical models relating fish abundance to spatial features) to explain overall variance in abundance is restricted just to the spatial component. It is therefore important to be able to quantify the contribution from the spatial component to total variance. This allows assessment of both the potential maximum performance of models as well as their actual performance in relation to the maximum. Furthermore, such variance partitioning offers insight into the relative roles of spatial and temporal (synchronous) factors in influencing population abundance and how these vary according to the geographical scale of sampling. Habitat models (HABSCORE), recently developed for Welsh streams, were used to explain variance in a ten year data set for which temporal and spatial variance could be estimated. Spatial factors explained between 46 and 62 % of overall variance within the Conwy system. This identifies the maximum limits for the performance of such models working at this scale. With the exception of poor performance for salmon parr, the habitat models accounted for 60-95 % of the spatial component, corresponding to 38-46 % of overall variance. In addition, variance structure was compared at four different levels of analysis: within tributaries on the Conwy, within nine different large separate river systems, within three areas and within the region of Wales. Spatial variance increased from 22-42 % (means) at within-tributary level to 42-65 % at regional level. In contrast, temporal variance (a measure of synchrony in population variability) decreased from 24-39 % within tributaries to 0.7 - 9.0 % at regional level. At within-rivers and larger scale the temporal variance displayed in 0 super(+) abundance was consistently lower than that for >0 super(+) fish. Some of the factors influencing variability at the different geographical scales are briefly discussed.

Codes: multi reach quant instream lulc temporal hem

Milner, N. J., R. J. Wyatt, and K. Broad. 1998. HABSCORE--applications and future developments of related habitat models. Aquatic Conservation: Marine and Freshwater Ecosystems 8: 633-644.

The role of habitat evaluation methods (HEM) is briefly reviewed in the context of contemporary fisheries management. Management requirements of HEMs for fisheries purposes include setting spawning targets, and assessing compliance against these targets, environmental impact assessment, habitat protection and restoration, survey design, classification and reporting of fish and habitat resources. Currently available or emerging HEMs are compared against these management applications. 2. HABSCORE is a system of salmonid stream habitat measurement and evaluation based on empirical models of fish density against combinations of site and catchment features. An outline is provided of the derivation, performance and applications of HABSCORE. 3. The effectiveness of HABSCORE and other HEMs depends on their ability to explain the spatial component of variance seen in fish population data. Variance analysis of HABSCORE performance shows how the relative importance of spatial and temporal variance alters at different geographical scales, the latter (indicative of synchronous variation) being much more important within small tributaries. HEMs based only on catchment features explain significant proportions of spatial variance, demonstrating their potential in catchment-scale evaluation. 4. Other contemporary HEMs considered include PHABSIM, procedures to transport spawning targets between rivers, fisheries classification, and habitat evaluation for restoration purposes. All of these have limitations in the management of habitat at catchment scale. Future fisheries applications, such as setting spawning targets or integrated catchment management planning, will probably require some combination of GIS-based, extensive classification and site-based field observations of habitat quality. This approach is being developed through the Fisheries River Habitat Inventory which links HABSCORE to a national fisheries classification system.

Codes: review philosophy microhab instream ifim hem warning

Mitchell, J., R. S. McKinley, G. Power, and D. A. Scruton. 1998. Evaluation of Atlantic salmon parr responses to habitat improvement structures in an experimental channel in Newfoundland, Canada. Regulated Rivers: Research & Management [Regul. Rivers: Res. Manage.] 14: 25-39.

Distributional patterns and microhabitat selection of Atlantic salmon (Salmo salar) parr were investigated in relation to habitat improvement structures in a controlled flow experiment channel at Noel Paul's Brook, Newfoundland. The channel consisted of six replicates, each containing three randomly arranged treatments. Each replicate included a control treatment with no habitat modification, a mid-channel treatment with a boulder cluster and low-head barrier dam, and a stream bank treatment with undercut banks and wing deflectors. The influence of size class, density, discharge and diurnal/nocturnal differences on microhabitat selection were evaluated. Results showed that the mid-channel treatment did not serve its purpose at lower discharges (0.032-0.063 m super(3) s super(-1)), and as a result was not the treatment of choice. However, as the discharge increased (0.13 m super(3) s super(-1)), more salmon took up residence in this treatment. In all experiments, greater depths were selected in the stream bank treatment, and salmon parr in the mid-channel treatment consistently selected positions closer to cover. Larger parr preferred greater depths and were found closer to the improvement structures. Benthic and drifting food availability were also estimated, and results showed that 'funnelling effects' of the drift were created near the structures. This study indicates that these structures have the potential to create favourable feeding sites, and provide the necessary physical characteristics required by salmon parr.

Codes: experi microhab qual instream hydro

Mitro, M. G. 2000. Sampling and Analysis Techniques and Their Application for Estimating Recruitment of Juvenile Rainbow Trout in the Henrys Fork of the Snake River, Idaho. Dissertation

Juvenile rainbow trout were sampled to quantify production and recruitment processes in the Henrys Fork, to identify factors limiting the trout population, and to propose management actions to improve natural recruitment. The study area was a 25-km river reach that varied in width from 50 to 150 m. I used distance sampling to identify spawning areas in the Henrys Fork and to quantify spawning activity therein. I developed and evaluated mark-recapture and removal techniques to address the inherent difficulties in the sampling and analysis of large abundances of age-0 salmonids over a large spatial scale. Mark- recapture data were collected from 100-m long sample areas. I found the Chao Mt estimator for mark-recapture data to have minimal bias and interval coverage close to the nominal level in simulations with mean capture probabilities (0.02-0.106) and rates of emigration (0-10%) based on actual Henrys Fork data sets. Three-pass removal data were collected along the banks in 15-m units. I developed and rigorously evaluated simple linear regression and mean capture probability models to predict abundance from the first-pass catch. These models worked particularly well for estimating abundance over a large spatial scale, allowing effort to be reallocated from intensively sampling few areas to sampling many areas with reduced effort, resulting in gains in estimate precision. These techniques were used to provide a comprehensive analysis of age- 0 rainbow trout recruitment in the Henrys Fork. There was suitable habitat throughout the study area to support the yearly production of 150,000 to 250,000 age-0 trout through summer and autumn. Recruitment to the fishery was limited by poor survival during their first winter. I identified a flow- survival relation for age-0 trout in a river section with complex bank habitat. The number of age-0 trout that survived their first winter was related to higher discharge during the latter half of winter. The higher discharge during the latter half of winter created more available habitat in the section with complex bank habitat and coincided with the loss of age- 0 trout from non-bank areas. Movement of age-0 trout was detected from river sections with simple bank habitat to sections with complex bank habitat. I recommended that winter discharge be managed to increase the availability of complex bank habitat, thereby improving recruitment of age-0 rainbow trout.

Codes: method quant popdyn spawn migrat instream hydro

Mobrand, L. E., J. A. Lichatowich, L. C. Lestelle, and T. S. Vogel. 1997. An approach to describing ecosystem performance `through the eyes of salmon'. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 54: 2964-2973.

The intent of this paper is to show that discussion of watershed health and salmon (Oncorhynchus sp.) performance can incorporate a much greater degree of complexity without the loss of clarity. More temporal-spatial detail can and should be included, more life history complexity, and more watershed-specific information. The framework and performance measures used in watershed and management generally, and salmon management specifically, are inadequate. The bottleneck metaphor is cited all too frequently as a basis for discussion. The bottleneck analogy is useful in understanding capacity, but capacity alone cannot explain observed responses of salmon populations to environmental change. An argument can be made that where protection and enhancement of weak stocks is the priority, productivity is a more critical variable. A framework built only around productivity and capacity is also not sufficient. It neglects the need for connectivity of habitats that salmon must pass through to complete their life histories. Adding life history diversity as the third component of performance provides the time and space structure needed to deal with connectivity while also allowing for integration of populations where they mingle.

Codes: philosophy basin lulc temporal warnings

Modde, T., and T. B. Hardy. 1992. Influence of different microhabitat criteria on salmonid habitat simulation. Rivers 3: 37-44.

This paper explores differences in predicted habitat using the Physical Habitat Simulation (PHABSIM) system given Suitability Index (SI) curves developed from data collected in three classes of macrohabitat (i.e., runs, riffles [including rapids], and eddies) versus composite curves using all available data. Rainbow trout, Oncorhynchus mykiss, and cutthroat trout, O. clarki, from the same populations used different microhabitats. The construction of focal velocity SI curves from pooled data on macrohabitat types produced a curve that did not represent actual fish use except at the margins of the curve. Individual habitat cells were classified during field collection of hydraulic transect data and used to compute useable habitat based on the macrohabitat-specific and composite SI curves. A comparison of weighted useable area (WUA) generated from macrohabitat-specific versus aggregate SI curves showed a 36% difference. (DBO).

Codes: reach quant microhab habitat instream ifim warning hem

Montgomery, D. R., E. M. Beamer, G. R. Pess, and T. P. Quinn. 1999. Channel type and salmonid spawning distribution and abundance. Canadian Journal of Fisheries and Aquatic Sciences 56: 377-387.

Analysis suggests that salmonid spawning patterns in mountain drainage basins of the Pacific Northwest are adapted to, among other things, the timing and depth of channel bed mobility. It is hypothesized that because the bed of pool-riffle and plane-bed reaches scours to a variable fraction of the thickness of alluvium, survival to emergence is favored by either burying eggs below the annual scour depth or avoiding egg burial during times of likely bed mobility. Conversely, annual mobility of all available spawning gravel in steeper step-pool and cascade channels favors either adaptations that avoid egg burial during times of likely bed mobility or selection of protected microhabitats. Consistent with these expectations, it was found that salmonid spawning distributions track channel slope distributions in several west-slope Pacific Northwest watersheds, implying that spatial differences in channel processes influence community structure in these rainfall-dominated drainage basins. More detailed field surveys confirm that different channel types host differential use by spawning salmonids and reveal finer-scale influences of pool spacing on salmonid abundance.

Codes: spawn qual habitat instream substrate hydro

Moore, K. M. S., and S. V. Gregory. 1988. Response of young-of-the-year cutthroat trout to manipulation of habitat structure in a small stream. Transactions of the American Fisheries Society 117: 162-170.

In Mack Creek, a third-order stream flowing through a 450-year-old coniferous forest in Oregon's Cascade Mountains, population size of young-of-the-year cutthroat trout Salmo clarki was positively correlated with length of stream edge and area of lateral habitat. Lateral habitats included backwaters and eddies at the margin of the channel that made up 10-15% of total stream area. Lateral habitat area was reduced at higher or lower streamflow, but the length of channel perimeter formed by lateral habitats was never less than twice the length of the reach. In an experimental manipulation of lateral habitat before the emergence of young fish from the redd, an increase in lateral habitat area of 2.4 times the area observed in control reaches resulted in a 2.2-times greater density of age-0 cutthroat trout. Young-of-the-year fish were virtually eliminated from stream sections with reduced area of lateral habitat. Growth was not affected by the greater density of fish in reaches with enhanced lateral habitat.

Codes: experi habitat quant offchann

Moore, K. M. S., and S. V. Gregory. 1988. Summer habitat utilization and ecology of cutthroat trout fry (Salmo clarki) in Cascade Mountain streams. Canadian Journal of Fisheries and Aquatic Sciences 45: 1921-1930.

Emergent cutthroat trout fry (Salmo clarki) were observed in the margins, backwaters, and side channels, collectively called "lateral habitats," of three study streams with different riparian vegetation. Most fry remained in these lateral habitats until the end of their first summer. The abundance of cutthroat fry was proportional to the area of lateral habitat in each of the study streams. Average size and growth rate of fry were related to the effect of site elevation on stream temperature and the influence of riparian vegetation on the availability of invertebrate food.

Codes: multi habitat quant offchann ripar wtemp

Moscrip, A. L., and D. R. Montgomery. 1997. Urbanization, flood frequency, and salmon abundance in Puget lowland streams. Journal of the American Water Resources Association [J. Am. Water Resour. Assoc.] 33: 1289-1297.

Urbanization history and flood frequencies were determined in six low-order streams in the Puget Lowlands, Washington, for the period between the 1940/50s and the 1980/90s. Using discharge records from USGS gauging stations, each basin was separated into periods prior to and after urban expansion. Four of the study basins exhibited significant changes in urbanized area, whereas two of the study basins exhibited only limited change in urbanized area and effectively serve as control basins. Each of the basins that experienced a significant increase in urbanized area exhibited increased flood frequency; pre-urbanization 10-year recurrence interval discharges correspond to 1 to 4-year recurrence interval events in post-urbanization records. In contrast, no discernible shift in flood frequency was observed in either of the control basins. Spawner survey data available for three of the study basins reveal systematic declines in salmon abundance in two urbanizing basins and no evidence for decreases in a control basin. These data imply a link between ongoing salmon population declines and either increased flood frequency or associated changes in habitat structure.

Codes: multi experi reach spawn lulc hydro temporal

Moyle, P. B., D. M. Baltz, and N. J. Knight. 1983. Instream flow requirements of native California stream fishes. Report OWRT-B-210-CAL(1).

Summaries are presented for two years of microhabitat studies on ten species of California stream fishes: rainbow trout, brown trout, speckled dace, California roach, hardhead, Sacramento squawfish, Lahontan redside, Sacramento sucker, Tahoe sucker, riffle sculpin, Paiute sculipin and the perch. The measurements of velocity, depth and substrate associated with each species can be used to construct habitat use curves useful for small streams in the

Sacramento Valley and in the Truckee drainage. Results imply that if instream flow recommendations are based on the requirements of just one species (usually rainbow trout in California), the populations of other species may change in unpredictable ways. Instream flow recommendations made using "habitat preference curves" constructed from data collected outside the impact area may not give an accurate picture of the effects of the changed flow regime on rainbow trout or other species.

Codes: multi instream microhab sppinter ifim warning hem

Murphy, M. L., and J. D. Hall. 1981. Varied effects of clear-cut logging on predators and their habitat in small streams of the Cascade Mountains, Oregon. Can. J. Fish. Aquat. Sci. 38: 137-145.

Assemblages of aquatic vertebrate and insect predators were inventoried in streams in old-growth and logged coniferous forests. Effects associated with logging depended on stream size, gradient, and time after harvest. Clear-cut sections where the stream was still exposed to sunlight (5-17 yr after logging) generally had greater biomass, density, and species richness of predators than old-growth (>450-yr-old) forested sections. Increases were greatest in small (first-order), high gradient (10-16%) streams, where clear-cut sites had both greater periphyton production and coarser streambed sediment than old-growth sites of similar size and gradient. Effects on predators were mixed in larger, lower gradient streams, where clear-cut sites showed accumulation of sediment and relatively small increases in periphyton production. Second-growth logged sections (12-35 yr after logging), reshaded by deciduous forest canopy, had lower biomass of trout and fewer predator taxa than old-growth sites.

Codes: multi reach quant instream substrate trophic ripar temporal

Murphy, M. L., C. P. Hawkins, and N. H. Anderson. 1981. Effects of canopy modification and accumulated sediment on stream communities. Transactions of the American Fisheries Society 110: 469-478.

Small streams differing in sediment composition were compared in logged and forested reaches to determine effects of accumulated fine sediment on stream communities under different trophic conditions. Three stages of forest community succession were studied in the Cascade Mountains: recently clear-cut areas without forest canopy (5-10 years after logging); second-growth forest with deciduous canopy (30-40 years after logging); and old-growth coniferous forest (>450 years old). One stream with mostly coarse sediment (56-76% cobble) and one with more fine sediment (5-14% sand and 23-53% gravel) were contrasted for each successional stage. In general, streams traversing open clear-cuts had greater rates of microbial respiration, and greater densities or biomasses of aufwuchs, benthos, drift, salamanders, and trout than did the shaded, forested sites regardless of sediment composition. We conclude that for these small Cascade Range streams, changes in trophic status and increased primary productivity resulting from shade removal may mask or override effects of sedimentation.

Codes: multi experi quant? lulc instream substrate trophic

Murphy, M. L., J. Heifetz, S. W. Johnson, K. V. Koski, and J. F. Thedinga. 1986. Effects of clear-cut logging with and without buffer strips on juvenile salmonids in Alaskan streams. Canadian Journal of Fisheries and Aquatic Sciences 43: 1521-1533.

To assess short-term effects of logging on juvenile Oncorhynchus kisutch, Salvelinus malma, Salmo gairdneri, and Salmo clarki in southeastern Alaska, the authors compared fish density and habitat in summer and winter in 18 streams in old-growth forest and in clearcuts with and without buffer strips. Buffered reaches did not consistently differ from old-growth reaches; clear-cut reaches had more periphyton, lower channel stability, and less canopy, pool volume, large woody debris, and undercut banks than old-growth reaches. In summer, if areas had underlying limestone, clear-cut reaches and buffered reaches with open canopy had more periphyton, benthos, and coho salmon fry (age 0) than old-growth reaches. In winter, abundance of parr (age > 0) depended on amount of debris. If debris was left in clear-cut reaches, or added in buffered reaches, coho salmon parr were abundant (10-22/100 m super(2)). If debris had been removed from clear-cut reaches, parr were scarce (< 2/100 m super(2)).

Codes: multi reach quant instream substrate trophic ripar lwd

Murphy, M. L., J. Heifetz, J. F. Thedinga, S. W. Johnson, and K. V. Koski. 1989. Habitat utilization by juvenile Pacific salmon (Oncorhynchus) in the glacial Taku River, Southeast Alaska. Canadian Journal of Fisheries and Aquatic Sciences 46: 1677-1685.

Habitat utilization by juvenile Pacific salmon (Oncorhynchus) was determined in summer 1986 by sampling 54 sites of nine habitat types: main channels, backwaters, braids, channel edges, and sloughs in the river; and beaver ponds, terrace tributaries, tributary mouths, and upland sloughs on the valley floor. Physical characteristics were measured at all sites, and all habitats except main channels (current too swift for rearing salmon) were seined to determine fish density. Each species of Oncorhynchus was absent from about one-quarter of the seining sites of each habitat type. The lower Taku River provides important summer habitat for juvenile salmon, but many suitable areas were unoccupied possibly because of their distance from spawning areas and poor access for colonizing fish.

Codes: reach quant offchann instream

Murphy, M. L., K. V. Koski, J. M. Lorenz, and J. F. Thedinga. 1997. Downstream migrations of juvenile Pacific salmon (Oncorhynchus spp.) in a glacial transboundary river. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 54: 2837-2846.

Migrations of juvenile Pacific salmon (Oncorhynchus spp.) in the glacial Taku River (seventh order) were studied to assess movement from upriver spawning areas (in British Columbia) into lower-river rearing areas (in Alaska). Differences between fyke-net catches in the river and seine catches in the river's estuary indicated that many downstream migrants remained in the lower river instead of migrating to sea. In particular, age-0 coho salmon (O. kisutch) and chinook salmon (O. tshawytscha) moved downriver from May to November but were not caught in the estuary. Age-0 sockeye salmon (O. nerka), coho presmolts, and other groups delayed entry into the estuary after moving downriver. Groups of juvenile coho (ages 0-2) were tagged from the fyke net with coded-wire to determine when they left the river. One-third of all tags recovered from sport and commercial fisheries occurred 2-3 years later, showing that many coho remained in fresh water for 1-2 years after moving to the lower river. Lower-river areas of large glacial rivers like the Taku River can provide essential rearing habitat for juvenile salmon spawned upriver and are important to consider in integrated whole-river management of transboundary rivers.

Codes: reach qual migrat temporal

Nakamoto, R. J. 1994. Characteristics of pools used by adult summer steelhead oversummering in the New River, California. Transactions of the American Fisheries Society 123: 757-765.

I assessed characteristics of pools used by oversummering adults of summer steelhead Oncorhynchus mykiss between July and October 1991 in the New River, northwestern California. Most fish occupied channel confluence pools and other pools of moderate size (200-1,200 m super(2)); these pools had less than 35% substrate embeddedness and mean water depths of about 1.0-1.4 m. Microhabitat occupied during daylight hours included cover provided by bedrock ledges and boulders where water velocity averaged 9.3 cm/s (range, 1-34 cm/s); steelhead densities under this cover were highest at the higher velocities. Fish also occupied areas with riparian shading and waters deeper than 1 m. I observed localized areas of cool water in some of the study pools. The availability of coolwater areas in pools did not increase adult fish use of those pools. The results of this study indicate that the distribution of summer steelhead in the New River during July-October is more strongly controlled by physical habitat characteristics than by the availability of thermal refugia.

Codes: habitat microhab quant substrate instream wtemp ripar

Nakano, S. 1995. Individual differences in resource use, growth and emigration under the influence of a dominance hierarchy in fluvial red-spotted masu salmon in a natural habitat. Journal of Animal Ecology 64: 75-84.

The relationships between dominance status and individual differences in foraging behaviour, habitat use, growth and emigration were examined for fluvial red-spotted masu salmon, Oncorhynchus masou ishikawai, in a mountain stream. Size-structured linear dominance hierarchies were recognized among individuals inhabiting the same stream pools. Observations on space utilization and foraging behaviour revealed fish to be either territorial or nonterritorial. Within each local pool, dominant fish exclusively occupied the mid or surface layer of the pools as foraging territories, whereas subordinates adopted nonterritorial tactics, primarily utilizing the bottom layer. Of the territorial fish, more dominant individuals tended to occupy focal points nearer the pool inlet, where they had priority of access to drifting food items. These fish showed higher actual foraging rates, feeding upon larger prey than their subordinates. This foraging advantage resulted in their having larger daily growth increments. The more dominant fish in each pool exhibited a more sedentary tendency than their subordinates. Population densities in the pools did not fluctuate appreciably owing to both emigration of nonterritorial subordinates and immigration. These results support the hypothesis that unequal resource partitioning among individuals subject to a dominance hierarchy plays an important role in their density-dependent population regulation.

Codes: habitat quant popdyn sppinter trophic

Nakano, S., F. Kitano, and K. Maekawas. 1996. Potential fragmentation and loss of thermal habitats for charrs in the Japanese archipelago due to climatic warming. Freshwater Biology 36: 711-722.

The upper thermal limits of the present distributions of two charr species, Dolly Varden, Salvelinus malma, and white-spotted charr, S. leucomaenis, in streams of the Japanese archipelago were examined using groundwater temperature as an index of thermal condition. The lower limits of the altitudinal distributions of Dolly Varden and white-spotted charr were delineated, respectively, by 8 and 16 degree C groundwater isotherms. The potential impact of future climatic warming on the geographical distribution, habitat extent and population fragmentation of each species was predicted at both the full archipelago and individual catchment levels. For Dolly Varden, analysis at the full archipelago level indicated a loss of 27.6, 67.2, 79.6 and 89.6% of the current geographical range, respectively, for a 1, 2, 3 and 4 degree C increase in mean annual air temperature. The present distribution area of white-spotted charr would likewise reduce by 4.1, 20.5, 33.8 and 45.6%, respectively. Based on the analyses of three individual catchments, one for Dolly Varden and two for white-spotted charr, the lower habitat boundaries for the two charr species could be expected to rise increasingly to higher elevations in each catchment as warming proceeded. As a consequence, there would be large reductions in mean habitat area, with increasing habitat fragmentation followed by localized extinctions of the two species.

Codes: multi qual reach lulc wtemp

Nakano, S., S. Kitano, K. Nakai, and K. D. Fausch. 1998. Competitive interactions for foraging microhabitat among introduced brook trout charr, Salvelinus fontinalis, and native bull charr, S. confluentus, and westslope cutthroat trout, Oncorhynchus clarki lewisi, in a Montana stream. Environmental Biology of Fishes 52: 345-355.

Competitive interactions for foraging microhabitat among introduced brook charr, Salvelinus fontinalis, and native bull charr, S. confluentus, and westslope cutthroat trout, Oncorhynchus clarki lewisi, were studied by species removal experiments in a tributary of the Flathead Lake and River system, northwestern Montana, focusing on brook charr influences on bull charr. When the three species were in sympatry, they interacted with each other, forming a size-structured, mixed-species dominance hierarchy in two stream pools. The influences of interference interactions were examined by measuring changes in five characteristics of foraging microhabitat and behavior, focal point height and velocity, cover use, and foraging rate and distance, after the successive removal of two species. Cutthroat trout removal resulted in increased foraging rates and distances, and decreased cover use for brook charr, but no changes for bull charr. After removal of brook charr from the two-species system, bull charr also increased foraging rates and distances and occupied more exposed positions. Moreover, total fish densities, which had initially decreased owing to the removal experiments, were partly compensated for by subsequent bull charr immigration, implying that competitive interactions with brook charr are an important factor in the mechanisms responsible for the regulation of bull charr densities, at least on a local scale.

Codes: experi microhab quant sppinter migrat

Naslund, I. 1987. Effects of habitat improvement on the brown trout (Salmo trutta L.) population of a north Swedish stream.

Habitat improvement structures have been installed in an attempt to restore the brown trout (Salmo trutta) populations in Sweden. To evaluate the effects of such structures a project was started in Laaktabaecken Creek, a tributary to the River Vindelaelven in Lapland. The fish population is dominated by resident brown trout with poor growth, early maturation and a short lifespan. Four types of habitat improvement structures were tested: stream deflectors; boulder dams; boulder groups; and a combination of stream deflectors and boulder dams. Boulder dams proved to be the most efficient structures. Brown trout densities increased by 200% and biomass by 400%.

Codes: experi quant instream

Naslund, I., E. Degerman, and F. Nordwall. 1998. Brown trout (Salmo trutta) habitat use and life history in Swedish streams: Possible effects of biotic interactions. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 55: 1034-1042.

To test if habitat use and life history of stream-dwelling brown trout (Salmo trutta) differed between allopatric and sympatric situations, three streams were compared with differing fish communities and data were used from a large national database containing electrofishing results from Swedish streams. In the three-creek study, allopatric brown trout used all habitats and shifted from nursery areas in riffles to pool habitats, where adult growth and survival were higher. Mainly females shifted habitat and this was undertaken after age 1. Sympatric brown trout under intense pressure from other fish species remained in the riffles throughout their life cycle. Under moderate pressure from other species, larger brown trout used slow-flowing habitats. Early growth was more rapid in sympatry. Sympatric brown trout also had a lower adult to juvenile growth ratio and lower adult survival and matured earlier than allopatric brown trout. The data from the nationwide database showed that frequency of occurrence and abundance of brown trout were negatively associated with the number of coexisting fish species. It was also verified that the habitat shifts between riffles and pools were more common and possibly more beneficial in terms of growth and survival in allopatry. In addition the existence of differences in juvenile growth between allopatric and sympatric populations was verified.

Codes: multi reach quant popdyn sppinter instream

Nass, B. L., K. K. English, and H. R. Frith. 1996. Assessment of summer rearing habitat and juvenile coho abundance in the Kwinageese River, B.C., 1992. Report

Habitat use by juvenile coho salmon (Oncorhynchus kisutch) was examined in the Kwinageese River, British Columbia, as part of the 1992-1993 Nisga'a Interim Measures Program (IMP). Foot and snorkel surveys were carried out during Aug and Sep to quantify wetted area and juvenile coho abundance by habitat and cover type. To determine if coho production was limited by available habitats, comparisons of observed total coho abundance and densities (by habitat type) were made with those presented in the literature. Linear densities of coho fry were the highest in small tributaries and pools with cover, followed by runs with cover. Runs and riffles with no cover had the lowest densities. Densities between habitats with cover and habitats without cover were significantly different in some comparisons. Side channels accounted for the greatest total linear habitat and the highest total abundance of juvenile coho. Pools contributed only 11.7% to total linear habitat but accounted for 16.5% of total abundance. Total estimated coho fry abundance was only 27% of the potential abundance estimated using a coho production model. Comparison of maximum density and biomass estimates for 29 B.C. streams revealed that the Kwinageese maximum for age 2 coho maximum was substantially higher than the maximum for all other streams surveyed. The average value for the 5 sites surveyed on the Kwinangeese River was only 20% of these maximum levels. Factors such as escapement or winter rearing habitat are more likely to be limiting coho production in the Kwinageese River than summer rearing habitat.

Codes: habitat quant instream

Nehlsen, W. 1997. Prioritizing watersheds in Oregon for salmon restoration. Restoration Ecology [Restor. Ecol.] 5: 25-33.

This paper describes an ecosystem approach (the Bradbury framework) to prioritizing watersheds for watershed restoration and salmon recovery, and gives an example of its application. The framework was applied at three spatial scales (in descending order) to prioritize (1) river basins within the north coast geographic area of Oregon (USA), (2) watersheds within the Tillamook Bay basin, and (3) restoration activities at the watershed level. Implementing the framework identified the Nehalem and Tillamook Bay basins as high priority for the north coast of Oregon. Within the Tillamook Bay basin, the Wilson, Kilchis, and Trask river watersheds emerged as high priority. Preliminary analysis indicated that controlling sediment sources by addressing upland road conditions and allowing floodplain and riparian ecosystems to recover are highestpriority protection and restoration activities within the Tillamook Bay basin. The sample application demonstrates that an ecosystem approach (the Bradbury framework) is particularly advantageous where data are limited, although previous identification of relatively intact areas is required. Implementing the framework is intended to lead to restoration of native species, but it may not provide immediate assistance for some species or populations of concern.

Codes: multi reach segment nofish substrate ripar philosophy

Nehring, R. B., and R. M. Anderson. 1993. Determination of population-limiting critical salmonid habitats in Colorado streams using the physical habitat simulation system. Rivers 4: 1-19.

The authors used the Instream Flow Incremental Methodology (IFIM) and Physical Habitat Simulation system (PHABSIM) to investigate the influence of stream discharge and the concomitant variation in habitat on wild rainbow (Oncorhynchus mykiss) and brown (Salmo trutta) trout populations in Colorado streams. We identified critical salmonid habitat limitations on 10 of the 11 streams studied over a 13-year period. The 2-4-week-old fry, egg incubation, and spawning life stages were most sensitive to critical habitat "bottlenecks." Linear regression analyses revealed statistically significant correlations (P less than or equal to 0.05) between weighted usable area (WUA), an index of physical habitat quality and quantity (determined using PHABSIM), and density (n/ha) of age-1 or -2 rainbow and brown trout in 10 of 11 streams studied. Correlations between WUA (based on mean monthly flow) and density were superior in both accuracy and precision in properly identifying population-limiting events compared to correlations between mean monthly stream discharge (during the critical time period) and trout density.

Codes: multi reach quant spawn instream microhab ifim hem

Nelson, R. L., W. S. Platts, D. P. Larsen, and S. E. Jensen. 1992. Trout distribution and habitat in relation to geology and geomorphology in the North Fork Humboldt River drainage, northeastern Nevada. Transactions of the American Fisheries Society 121: 405-426.

The authors studied the existing distribution of native Lahontan cutthroat trout Oncorhynchus clarki henshawi and exotic brook trout Salvelinus fontinalis with respect to geologic and geomorphic land-classes in the upper North Fork Humboldt River drainage, Nevada. We evaluated habitat conditions in study sites to determine which measured components of habitat structure provided the best discriminators among study stream reaches in the different land-classes and among trout-supporting and unpopulated study reaches. At a finer level of resolution, we used the habitat attributes with the most discriminatory power to plot the distributions of study areas by land-class and by presence or absence of trout along coordinate axes reflecting environmental gradients defined by these attributes. Elevation, substrate embeddedness, and streamflow were the variables with the most discriminatory power among land-classes defined by parent geologic material (geologic district), but gravel abundance in the substrate was more useful than streamflow in further discriminating among land-classes at the lower-level classification defined by geomorphic character (landtype association).

Codes: multi qual lulc substrate

Newman, R. M., and T. F. Waters. 1989. Differences in brown trout (Salmo trutta) production among contiguous sections of an entire stream. Canadian Journal of Fisheries and Aquatic Sciences 46: 203-213.

Production dynamics of a wild brown trout (Salmo trutta) population were examined for 3 yr in each of eight contiguous 305-m-long sections that constituted the entire length of South Branch Creek, a limestone stream in southeastern Minnesota. Standing stock and production also differed significantly among sections, but relative differences among sections were fairly constant over the 3 yr. The most productive sections had standing stocks and production rates that were 1.5-2 times higher than the least productive sections. Year strongly influenced growth rate, with growth in 1982 almost double that in 1981, but growth rates did not differ significantly among sections. Habitat differences among sections appeared to regulate density, size, standing stock, and production. Factors that affected the entire stream influenced recruitment and growth.

Codes: reach quant popdyn instream temporal

Nickelson, T. E., and P. W. Lawson. 1998. Population viability of coho salmon, Oncorhynchus kisutch, in Oregon coastal basins: Application of a habitat-based life cycle model. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 55: 2383-2392.

To assess extinction risk for Oregon coastal coho salmon, Oncorhynchus kisutch, a life cycle model was developed based on habitat quality of individual stream reaches estimated from survey data. Reach-specific smolt output was a function of spawner abundance, demographic stochasticity, genetic effects, and density- and habitat-driven survival rates. After natural mortality and ocean harvest, spawners returned to their natal reaches. Populations in reaches with poor habitat became extinct during periods of low marine survival. With favorable marine survival, high productivity reaches served as sources for recolonization of lower quality reaches through straying of spawners. Consequently, both population size and distribution expanded and contracted through time. Within a reach, populations lost resilience at low numbers when demographic risk factors became more important than density-dependent compensation. Population viability was modeled for three coastal basins having good and moderate habitat and constant habitat conditions, extinction risk in 99 years was negligible in basins with good and moderate habitat and 5-10% in the basin with poor habitat. Reductions in habitat quality up to 60% in 99 years resulted in reduced coho salmon populations in all basins and significantly increased extinction risk in the basin with poor habitat.

Codes: multi modeling risk reach quant popdyn instream

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49: 783-789.

Habitat use by juvenile coho salmon (Oncorhynchus kisutch) during spring, summer, and winter was examined in Oregon coastal streams. Coho salmon fry were most abundant in backwater pools during spring. During summer, juvenile coho salmon were more abundant in pools of all types then they were in glides or riffles. During winter, juvenile coho salmon were most abundant in alcoves and beaver ponds. Because of the apparent strong preference for alcove and beaver pond habitat during winter and rarity of that habitat in coastal streams, we concluded that if spawning escapement is adequate, the production of wild coho salmon smolts in most coho salmon spawning streams on the Oregon Coast is probably limited by the availability of adequate winter habitat.

Codes: multi experi quant habitat instream offchann

Nickelson, T. E., M. F. Solazzi, S. L. Johnson, and J. D. Rodgers. 1992. Effectiveness of selected stream improvement techniques to create suitable summer and winter rearing habitat for juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49: 790-794.

We examined the use of constructed pools by juvenile coho salmon (Oncorhynchus kisutch) during summer and winter. Log, gabion, and rock structures placed across the full stream width provided good summer habitat but poor winter habitat for juvenile coho salmon. Rearing densities in constructed habitats during summer and winter were generally similar to those in natural habitats of the same type, except that constructed dammed pools supported lower densities during winter than natural dammed pools. The addition of brush bundles to pools created by full-stream-width structures increased the density to juvenile coho salmon in dammed pools during winter, but not in plunge pools. We concluded that the development of off-channel habitat has the greatest potential to increase production of wild coho salmon smolts in Oregon coastal streams.

Codes: multi experi quant habitat lwd instream offchann

Niemelä, E., M. Julkunen, and J. Erkinaro. 1999. Revealing trends in densities of juvenile Atlantic salmon, Salmo salar L., in the subarctic River Teno using cluster analysis on long-term sampling data. Fisheries Management and Ecology [Fish. Manage. Ecol.] 6: 207-220.

The density of juvenile Atlantic salmon, Salmo salar L., was monitored at 57 sites representing different habitats in the River Teno and two of its major tributaries from 1979 to 1995. Cluster analyses were used to combine sites with similar densities and to study trends in densities within clusters. It was found that management measures have played an important role in maintaining salmon stocks and there was some evidence of increasing juvenile salmon densities. Parr densities decreased significantly in one cluster containing 45% of the sites studied in the River Utsjoki, whereas densities increased significantly in one cluster in the River Teno and in one cluster in the River Inarijoki containing 38% of the sites in these rivers. Fry densities increased significantly in two clusters containing 16% of all the sites studied in the three rivers. In general, the mean densities in successive years in the clusters were independent. The results demonstrate the value of long-term monitoring in ecological investigations.

Codes: multi reach basin quant temporal noenv

Nislow, K. 1998. The Relationship Between Habitat and Performance of Age-0 Atlantic Salmon.

In this study, I examined the interactive effects of prey and physical habitat on foraging, habitat selection, growth, and survival of age-0 Atlantic salmon, Salmo salar. I combined field observations of salmon behavior, surveys of habitat and prey availability, laboratory and field experiments, and computer modeling to test whether differences in prey and habitat affect performance parameters of age-0 salmon. Understanding these effects is critical for the restoration of Atlantic salmon to their historic range, and provides a test of basic ecological theory concerning early life history energetics of fish populations. Differences in prey and habitat were strongly associated with salmon performance. Salmon foraging rates were higher in a high-invertebrate abundance vs. a low-abundance stream. However, foraging rates were uncorrelated with invertebrate abundance in individual territory locations within streams, and individuals did not preferentially establish territories in locations with the highest prey abundance. Instead, salmon preferred microhabitat locations where both prey abundance, and the ability to detect and capture prey, were relatively high. Small, early season fish (May-June) preferred low-current speed microhabitats, while larger, late season fish (July- August) preferred high-current speeds. Loss rates (=loss of fish due to mortality and emigration) of age-0 salmon were significantly lower in streams with a greater percentage of preferred early season habitat, but were uncorrelated with availability of late season habitat. Habitat manipulation via the introduction of large woody debris and boulder structures increased preferred early season habitat, and had a neutral effect on invertebrate prey, suggesting a net positive impact on age-0 salmon. Bioenergetics modeling confirmed that differences in habitat and prey translated into major predicted differences in growth rate potential between streams and seasons, and reinforced the importance of early season habitat in influencing the potential for streams to successfully rear salmon through their first summer. This study demonstrates that early life history energetics can explain differences in the growth and survival of stream fish populations. Effects on early life history habitat conditions are therefore likely to be critical for Atlantic salmon management and restoration efforts.

Codes: experi microhab quant popdun lwd instream trophic

Nislow, K. H., C. Folt, and M. Seandel. 1998. Food and foraging behaviour in relation to microhabitat use and survival of age-0 Atlantic salmon. CJFAS 55: 116-127.

Using underwater snorkeling observations and field experiments, the influence was examined of food availability on foraging behavior, habitat use, and survival of age-0 Atlantic salmon (Salmo salar) during the critical first-summer growth period. While most feeding attempts were directed at drifting invertebrate prey, a higher rate was found of benthic feeding forays than previously reported for salmon. Greater food abundance was associated with higher feeding foray rates, more time allocated to foraging, occupancy of higher microhabitat velocities, and greater first-year survival between two study streams. Experimental drift reduction reduced drift foray rates and triggered a change in behavior to increased benthic feeding. In contrast, within a single stream, greater predicted invertebrate drift in high-velocity microhabitats was unrelated to either microhabitat occupancy or drift foray rates of age-0 salmon. It is suggested that in some situations, salmonid foraging is related more directly to overall prey density than to the availability of high-velocity, high drift rate microhabitats. Differences in resource tracking (increased foraging, growth, or survival with increased food abundance) at different scales, along with the use of alternative predation models, underscore the importance of considering behavior when linking food resources to growth and survival of stream salmonids.

Codes: experi microhab qual trophic

Nislow, K. H., C. L. Folt, and D. L. Parrish. 1999. Favorable foraging locations for young Atlantic salmon: application to habitat and population restoration. Ecological Applications 9: 1085-1099.

Declines in the populations of salmonid fishes have generated major interest in conservation and restoration of wild populations and river habitats. We used a foraging-based model, combined with field observations and surveys, to predict individual habitat use, and to assess the effects of stream habitat conditions and management practices on the potential for reestablishing Atlantic salmon, Salmo salar. Using a model based on a simple trade-off between increasing prey encounter rate and decreasing salmon capture success with increasing stream current velocity, we predicted favorable foraging locations for salmon in their first (age-0) spring and summer. We tested, in six streams, whether (1) salmon preferred locations (=microhabitats) that were predicted to yield high consumption rates, (2) salmon growth and survival was greater in streams with a greater proportion of preferred, profitable, microhabitats, and (3) stream habitat remediation (introduction of large in-stream structures such as large woody debris) increased the availability of microhabitats found to be preferred by salmon, and energetically profitable. Salmon early in their first season (May-June) were predicted to obtain the highest consumption rates (within 10% of maximum) in microhabitats with a narrow range of relatively slow current velocities (0.08-0.18 m/s). In contrast, later in the season (July-August) fish were predicted to obtain highest consumption rates over a wide range of fast current velocities (0.21-0.57 m/s). Salmon in both the early and late seasons showed strong preferences (use in proportion to availability) for microhabitat in velocity categories predicted to provide high consumption. Streams with the greatest proportion of preferred early-season, but not late-season, microhabitats retained a higher proportion of salmon as measured at the end of the first summer. Stream habitat remediation increased the amount of preferred early-season microhabitat and did not negatively affect invertebrate prey abundance, or the amount of preferred late-season microhabitats. Thus, the availability of favorable foraging areas for juveniles significantly improves the retention of salmon during the critical first summer, and stream remediation provides better foraging habitat during this important period. Our results are encouraging for broader application to identify sites that show promise for salmon reintroduction, and to help guide restoration of particular sites to provide suitable habitat.

Codes: modeling microhab quant trophic lwd

O'Grady, M. F. 1993. Initial observations on the effects of varying levels of deciduous bankside vegetation on salmonid stocks in Irish waters. Aquaculture and fisheries management 24: 563-573.

The effects of varying levels of deciduous bankside vegetation on salmonid stocks in Irish rivers were investigated. In summertime, when marginal vegetation limited the extent of incident light reaching the river bed, a marked decline in both juvenile salmon, Salmo salar, and juvenile and adult trout, Salmo trutta, numbers were observed relative to stocks in adjacent areas with a less dense canopy. This appears to be a countrywide phenomenon in all available salmonid habitats. In the case of both juvenile salmon and all trout numbers a correlation is evident between the extent of shade, as measured in terms of the reduction in aquatic vegetation, and fish numbers, which fall as shade levels increase. Data also suggest that the length of tunnelled channel, upstream of tunnelled sites electrofished, seems to influence the standing crop of juvenile salmon with numbers of these fish falling with increasing tunnel length. This relationship is not evident in relation to trout numbers.

Codes: experi multi reach quant ripar

Paulsen, C. M., and T. R. Fisher. 2001. Statistical Relationship Between Parr-to-Smolt Survival of Snake River Spring-Summer Chinook Salmon and Indices of Land Use. TAFS 130: 347-358.

We used simple regression models to demonstrate an association between land use and parr survival of chinook salmon Oncorhynchus tshawytscha from overwintering areas in the Snake River drainage of Idaho and Oregon to the first main-stem dam encountered during emigration to the Pacific Ocean. We used data on tagged (passive integrated transponder tags) releases of naturally produced Snake River spring-summer chinook parr and subsequent tag detections, as well as indices of land use, vegetation, and road density. We spot-checked the land-use and vegetation indices in a field survey of spawning and rearing areas in the summer of 1999, and we believe that they are reliable indicators of land-use patterns. The models also employed month of release, length of parr at release, and a drought index as independent variables. The models were developed and tested using parr tagged from 1992 through 1998. Age-0 parr that reared in wilderness areas (a land-use category; not necessarily federally designated Wilderness Areas) had the highest survival during their last 6-9 months of freshwater residence. In contrast, parr that reared in young, dry forests (typically, intensively managed timber lands) had the lowest survival. Similarly, parr that reared in areas of low road density had substantially higher survival than those in areas of high road density. We concluded that in the area studied there is a close association between land-use indices and survival of chinook salmon parr during their last 6-9 months of freshwater residence. This analysis suggests that road-building and associated land-use activities in the region may have a detrimental effect on the survival of juvenile chinook salmon and that mitigative changes in these activities could be warranted because Snake River spring-summer chinook salmon are listed as threatened under the Endangered Species Act.

Codes: multi basin popdyn quant lulc hydro

Pert, E. J., and D. C. Erman. 1994. Habitat use by adult rainbow trout under moderate artificial fluctuations in flow. Transactions of the American Fisheries Society 123: 913-923.

Adult rainbow trout Oncorhynchus mykiss were observed in a 20-m reach of river to determine habitat use (at four flow levels) and preference (at two flow levels) under daily fluctuations in discharge from a hydropower peaking operation. Maximum increase in discharge was threefold (from 1.6 to 5.1 m super(3)/s), which is small compared with that of some hydropower peaking operations. Available habitat (based on velocity and depth) was different under low and high flows. At the low discharge level, nearly twice as much of the lowest velocity-class (0.00-0.15 m/s) and eight times more of the shallowest depth-class (0.0-0.02 m) were available. Distributions of adult habitat use revealed that fish focal point and water column velocities increased with increasing discharge. At the highest discharge levels, more fish were found in the deepest water, and the fish assumed positions closer to the streambed, than at the three lower discharges. Fish were usually associated with boulders at all discharges. Habitat preference shifted to deeper and faster water as discharge increased. Two types of individuals were identified on the basis of habitat use under various discharge levels. Pattern-1 individuals displayed strong site fidelity and used higher focal point velocities at higher discharges. Pattern-2 individuals were generally more mobile than pattern-1 individuals and showed no relationship between discharge and focal point velocity. Repeated observations made on individually marked fish indicated that description of habitat use and preference in terms of microhabitat may yield a false interpretation of optimal habitat for the populations as a whole. It is likely that few individuals in a population of territorial fish occupy the optimal habitat. Interpreting the most frequently used microhabitat as optimal habitat for a population is probably incorrect and could result in erroneous predictions of available habitat based on instream flow assessment models.

Codes: qual habitat microhab hydro instream warning hem

Petrosky, C. E., and T. B. Holubetz. 1986. Idaho Habitat Evaluation for Off-Site Mitigation Record: Annual Report 1985.

The Idaho Department of Fish and Game (IDFG) conducted an evaluation of existing and proposed habitat improvement projects for anadromous fish in the Clearwater River and Salmon River drainages during 1984 and 1985. Projects included in the evaluation are funded by or proposed for funding by the Bonneville Power Administration under the Northwest Power Planning Act. The Clearwater River and Salmon River drainages account for virtually all of Idaho 's wild and natural production of summer steelhead and spring and summer chinook salmon, as well as a remnant run of sockeye salmon. Although a majority of the habitat still available to steelhead and salmon is high quality, man 's activity in Idaho has degraded many streams. Sedimentation has increased with widespread logging, road building, and associated activities. Intensive livestock grazing near streams has removed riparian vegetation, changed stream morphology, and accelerated soil erosion. Mining has had profound effects in parts of the drainages through stream channel alterations, discharge of toxic effluents, and increased sedimentation. Irrigation withdrawals have reduced flows and increased water temperatures, often to critical levels for steelhead and salmon during summer. Primary objectives of this evaluation project are to: (1) document physical changes that result from habitat enhancement; (2) measure changes in steelhead and chinook parr/smolt production attributable to all habitat enhancement projects; (3) determine project effectiveness to guide future enhancement activity, and (4) determine benefits in terms of increased smolt and adult production resulting from each habitat enhancement project. General level studies on each project will provide a large database that can be used to predict response of increased or decreased fish production from a physical change in anadromous fish habitat. This data should assist sponsors of future habitat enhancement projects in more accurately estimating fishery benefits of their proposed projects. This database will also assist in defining limiting habitat factors for the various types of streams in Idaho. (Lantz-PTT).

Codes: reach multi substrate hydro wtemp quant? Datasource

Platts, W. 1991. Livestock grazing. Pages 389-423. In The influence of forest and rangeland management on salmonids and their habitat. W. R. Meehan, editors. American Fisheries Society Special Publication 19, Bethesda, MD.

Codes: review multi reach quant instream graz temporal economic

Platts, W. S., and R. L. Nelson. 1988. Fluctuations in trout populations and their implications for land-use evaluation. North American Journal of Fisheries Management 8: 333-345.

The authors describe the magnitude of fluctuations in trout populations in several widely separated streams in the intermountain region of the western US, and consider their potential effect on land-management planning. Trout populations included native and exotic species, self-reproducing and hatchery-maintained populations, and assemblages that ranged from monospecific to diverse. Annual fluctuations in population statistics were generally large, and were related to geographic setting and trout species. Except in cases of irregular occurrence, populations of brook trout Salvelinus fontinalis, particularly in Rocky Mountain study areas, were numerically the most stable; those of allopatric cutthroat trout Salmo clarki (= Oncorhynchus) in the Great Basin were the least stable numerically. Total salmonid community tended to fluctuate less than individual populations, except when fry of anadromous chinook salmon Oncorhynchus tshawytscha were present. Inherent trout population fluctuations must be considered within the framework of land-use planning if fishery goals are to be achieved. Habitat-based models to evaluate the effects of land uses and habitat enhancement efforts frequently fail to incorporate these fluctuations. Such models often have little utility in predicting sizes or biomass of salmonid populations in the intermountain west.

Codes: quant lulc sppinter temporal warning hem

Platts, W. S., and R. L. Nelson. 1989. Stream canopy and its relationship to salmonid biomass in the Intermountain West. North American Journal of Fisheries Management 9: 446-457.

To assess prevailing stream canopy (riparian overstory) conditions on representative streams in the northern Rocky Mountains and the Great Basin of the western USA, we measured several riparian habitat components, including canopy density, light intensity, unobstructed sun arc, and average potential daily thermal input in grazed and ungrazed (rested) portions of each stream. We also determined to what extent, if any, these habitat components were correlated with salmonid biomass and whether either they or salmonid biomass differed significantly between geogrpahic regions or between grazed or rested pastures. Unobstructed sun arc was significantly and positively correlated with thermal input ($P < 0.01$), and it was the best overall predictor of salmonid biomass per unit volume (r super(2) = 0.58). Thermal input was a better predictor of salmonid biomass per unit volume in the Great Basin (r super(2) = 0.92) than in the Rocky Mountains (r super(2) = 0.50). #(foregoing abstract from CSA incomplete, Author's abstract from another source follows)#

To assess prevailing stream canopy (riparian overstory) conditions on representative streams in the northern Rocky Mountains, and the Great Basin of the western USA, several riparian habitats, including canopy density, light intensity, unobstructed sun arc, and average potential daily thermal input were measured in grazed and ungrazed (rested) portions of each stream. It was also determined to what extent, if any, these habitat components were correlated with salmonid biomass and whether either they or salmonids differed significantly between geographic regions or between grazed or rested pastures. Unobstructed sun arc was significantly and positively correlated with thermal input, and it was the best overall predictor of salmonid biomass per unit volume. Thermal input was a better predictor of salmonid biomass per unit volume in the Great Basin than in the Rocky Mountains, where the thermal regime may exert more influence on fish populations. Mean estimates of fish biomass per unit volume differed significantly between the Great Basin (55.9 g/cum) and Rocky Mountain (13.1 g/cum) study areas and were better related to stream canopy attributes than biomass estimates based on stream surface area; in the Great Basin study areas, the two types of biomass estimates were only weakly correlated with each other. In the Rocky Mountains, ungrazed sites generally had more canopy cover than grazed sites. In the Great Basin study areas, however, differences in canopy were unimportant and were probably related to local management practices in several cases. (Author 's abstract).

Codes: reach multi experi graz ripar quant

Poff, N. L., and A. D. Huryn. 1998. Multi-scale determinants of secondary production in Atlantic salmon (Salmo salar) streams. Canadian Journal of Fisheries and Aquatic Sciences 55: 201-217.

Understanding variation in the freshwater production of Atlantic salmon across its range is a critical aspect of the species' conservation, restoration, and management. We focus on how environmental factors operate at four hierarchical scales (region, watershed, reach, local habitat) to influence the production and survivorship of juvenile salmon and the production of their invertebrate food base. Using published, quantitative information about invertebrate production in small, cold streams characteristic of Atlantic salmon nursery steams, we estimate expected maximum salmon production will be ca. 9 (range 6-22) g wet mass times m super(-2) times year super(-1), which compares favorably with reported literature values of <1 to 17 g times m super(-2). We highlight some empirically based, shortcut approaches to estimating invertebrate production that may be particularly useful for evaluating salmonid production across a range of scales. We also consider how availability of invertebrate prey may influence salmon production. As a synthesis, we integrate existing information into a multi-scale framework by making qualitative predictions (hypotheses) about expected patterns of invertebrate and salmon production at different habitat scales. We then develop quantitative, heuristic scenarios that predict (hypothesize) how salmon and invertebrate production will change in response to selected physicochemical and non-trophic habitat limitations operating at the watershed (geology, land use) and reach (channel form, canopy) scales. Predicted values, which fall within the range of observed values for Atlantic salmon streams, demonstrate that a multi-scale habitat perspective can provide important insights into local to regional variation in the production of Atlantic salmon across its range and thus contribute to Atlantic salmon conservation, restoration, and management.

Codes: modeling reach basin quant trophic ripar lulc

Pradel, R. 1996. Utilization of capture-mark-recapture for the study of recruitment and population growth rate. Biometrics 52: 703-709.

#Has same limitations as any multiple c-m-c approach - e.g., closed population, catchability independent of age and habitat, assumption of animals behaving independently and identically. It also needs uniquely identifiable tags with a sufficiently high probability of recapture over extended time periods in order to estimate recruitment and/or survival.#

Codes: quant modeling

Quinn, T. P., and N. P. Peterson. 1996. The influence of habitat complexity and fish size on over-winter survival and growth of individually marked juvenile coho salmon (Oncorhynchus kisutch) in Big Leaf Creek, Washington. CJFAS 53: 1555-1564.

Wild juvenile coho salmon (Oncorhynchus kisutch) were individually marked in October 1990 and 1991 to evaluate the effects of habitat complexity and fish size on over-winter survival in Big Beef Creek, Washington. Habitat complexity was quantified for the habitat unit where the fish were collected and, in 1991, also for the 500-m reach downstream from the collection site. Survival, estimated from recovery of marked smolts at the stream's mouth, differed between years (25.4 and 46.2%) and also varied among habitat units and reaches within years. Survival was at most weakly correlated with complexity of the habitat units but was strongly correlated with the quantity of woody debris and density of habitat units in the 500-m reach, and distance from the estuary. Because distance covaried with habitat complexity, it was not possible to ascertain which factor had the primary influence on survival. Larger fish generally survived at a higher rate than smaller individuals. Fish tagged above William Symington Lake were smaller in the fall but larger as smolts and had higher survival rates than those tagged below the lake. Results reveal complex relationships between size, habitat, and growth that may affect over-winter survival and subsequent life history events.

Codes: reach quant popdyn lwd instream

Reeves, G., J. D. Hall, T. Roelofs, T. Hickman, and C. Baker. 1991. Rehabilitatiing and modifying stream habitats. Pages 519-557. In The influence of forest and rangeland management on salmonids and their habitat. W. R. Meehan, editors. American Fisheries Society Special Publication 19, Bethesda, MD.

Codes: review habitat basin hydro warning

Reeves, G. H., F. H. Everest, and J. R. Sedell. 1991. Responses of anadromous salmonids to habitat modification: How do we measure them? Edited by J. Colt and R. J. White. AFS, BETHESDA, MD 62-67 p.

Responses of anadromous fish populations to habitat manipulations are seldom measured. The primary reasons given for this neglect are inadequate funds, personnel, and time. This paper examines ways in which biological responses to habitat manipulation can be evaluated at different stages in the life history of anadromous salmonids. Responses that can be measured are changes in numbers of adult fish, changes in numbers of juvenile fish, and changes in numbers of smolts leaving a stream or stream system. The authors assess the merits of each approach and conclude that changes in smolt numbers are the best way to evaluate the effect of habitat manipulation projects on anadromous salmonid populations. Evaluation programs should be developed on a basin or subbasin scale because reach or site scales provide an inadequate context for evaluating change. Evaluations should also consider the response of the entire salmonid community to changes in habitat rather than the response of a single or target species.

Codes: philosophy method instream basin

Reeves, G. H., F. H. Everest, J. R. Sedell, and D. B. Hohler. 1990. Influence of habitat modifications on habitat composition and anadromous salmonid populations in Fish Creek, Oregon, 1983-88. Annual report, 1988. Report DOE/BP/16726-5.

Modification of degraded habitats to increase populations of anadromous salmonids is a major focus of management agencies throughout the Pacific Northwest. Inherent in implementing habitat improvements is the need for quantitative evaluation of the biological and physical effects of such work. While it is not economically possible to thoroughly evaluate every habitat project, it is essential that intensive evaluations be done on selected representative projects. One such evaluation program has been underway since 1982 on Fish Creek, a tributary of the Clackamas River near Estacada, OR. Habitat modification has been done by the USDA Forest Service, Estacada Ranger District, Mt. Hood National Forest with funding provided in part by the Bonneville Power Administration (BPA). The USDA Forest Service, Anadromous Fish Habitat Research Unit, Pacific Northwest Research Station (PNW), Corvallis, OR is charged with: evaluating the biological and physical responses to habitat modifications on a basin scale; and developing a cost-benefit analysis of the program. The objectives of this paper are to: report 1988 observations of biological and physical changes in habitat, salmonid populations, and smolt production in Fish Creek, and examine preliminary trends in fish habitat and populations related to habitat improvement over the period 1983-1988. The authors have prefaced the trends in the latter objective as preliminary because we believe it could take a minimum of 10 years before the full biological and physical responses to habitat work are realized.

Codes: reach quant temporal instream

Reeves, G. H., J. D. Hall, and S. V. Gregory. 1997. The impact of land-management activities on coastal cutthroat trout and their freshwater habitats. Sea Run Cutthroat Trout: Biology, Management, And Future Conservation., American Fisheries Society, Oregon Chapter, Corvallis, Oregon 138-145.

Relatively few studies of the impact of land-management activities on anadromous salmonids and their freshwater habitats have considered coastal cutthroat trout. Those that included cutthroat trout have generally found that they are susceptible to the effects of land-management activities. Numbers of cutthroat trout juveniles and smolts have declined following such activities as timber harvest. Their numbers may remain depressed for extended periods following such disturbances, for reasons that are not clear. We offer an explanation: changes in pool depth and complexity may reduce habitat suitability, which may in turn reduce the carrying capacity of the stream or reduce survival by forcing juveniles to compete with other species. Coastal cutthroat trout may be the "canary in the coal mine" with respect to the integrity of aquatic ecosystems throughout their range. Management policies must be directed at arresting the decline in quality and quantity of freshwater habitat if coastal cutthroat trout populations are to persist.

Codes: review philosophy instream ripar sppinter

Reeves, G. H., D. B. Hohler, B. E. Hansen, F. H. Everest, J. R. Sedell, T. L. Hickman, and D. Shively. 1997. Fish habitat restoration in the Pacific Northwest: Fish Creek of Oregon. Watershed Restoration: Principles and Practices., American Fisheries Society 5410: 20814-2199.

The decline of anadromous salmonids in the Pacific Northwest of the United States is attributable to a suite of factors that includes overexploitation in sport and commercial fisheries, habitat alteration, migration barriers, variable ocean conditions, and influence of hatchery practices. A combination of these factors is generally associated with the depressed status of almost every population. The factor most associated with the decline of individual populations is habitat alteration, which includes a decline in the quantity and quality of freshwater habitat. Habitat in streams used by anadromous salmonids in the Pacific Northwest has been simplified as a consequence of many human activities. Simplification includes the loss of habitat, quality, diversity, and complexity. Such changes have occurred as a result of past as well as more recent activities and are common throughout much of the range of anadromous salmonids in western North America.

Codes: philosophy instream ripar

Reid, L. M. 2001. The epidemiology of monitoring. Journal of the American Water Resources Association 37: 815-820.

#only monitoring studies that had failed were considered #

Codes: review method design philosophy warnings

Reinhardt, U. G., and M. C. Healey. 1998. Predation risk as an opportunity for compensatory growth in juvenile coho salmon?

The present study explores the reasons for the apparent higher susceptibility of small individuals to predation. Field and laboratory observations were made of size-dependent foraging strategies in age-0 coho salmon (Oncorhynchus kisutch) under predation risk. In laboratory stream tanks groups of juvenile coho salmon were given a choice of a safe habitat and a habitat offering the same amount of food but associated with simulated predation risk from a model predator. Fish that made use of a risky pool were smaller and fewer in numbers than their counterparts in the safe pool. Overall growth rates were depressed and the difference in growth rates between small and large individuals was reduced when compared with control experiments without simulated predation. This suggests that large fish behaved in a risk-averse manner compared to small individuals, the latter making use of enhanced feeding opportunities indirectlyprovided by the presence of the predation threat. Speculation is that in a natural environment, the presence of predators may serve to depress growth rates in a population through risk-avoidance behaviour, but may allow for growth compensation among size classes within a cohort. Befor removal of predators as paart of an enhancement scheme for salmonids, managers may consider the potential effect not only on mortality rates but also on growth patterns in a population of fish. (D.B.O.).

Codes: experi microhab lab popdyn

Richards, C., P. J. Cernera, M. P. Ramey, and D. W. Reiser. 1992. Development of off-channel habitats for use by juvenile chinook salmon. North American Journal of Fisheries Management 12: 721-727.

Fisheries habitat improvement frequently requires the exploitation of existing or artificial features of stream channels and associated floodplains. Along the Yankee Fork of the Salmon River, four series of off-channel mining dredge ponds were connected to the river by excavating channels; surface-water control structures were installed to regulate flow through each series of ponds. The project was created to increase rearing habitat for juvenile chinook salmon Oncorhynchus tshawytscha. Highest fish densities (5.2/m squared) in the newly constructed pond series were in connecting channel habitats. These densities were higher than those reported in other streams and may have been related to the hatchery origin of the stocked fish. Densities observed in the ponds were similar to those reported in natural habitats. Addition of habitats through incorporation of dredge ponds increases management options for rebuilding chinook salmon populations in the stream.

Codes: quant offchann habitat

Rieman, B. E., D. C. Lee, and R. F. Thurow. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 17: 1111-1125.

We summarized existing knowledge regarding the distribution and status of bull trout Salvelinus confluentus across 4,462 subwatersheds of the interior Columbia River basin in Oregon, Washington, Idaho, Montana, and Nevada and of the Klamath River basin in Oregon, a region that represents about 20% of the species' global range. We used classification trees and the patterns of association between known distributions and landscape characteristics to predict the likely distribution of bull trout in unsampled subwatersheds. Bull trout are more likely to occur and the populations are more likely to be strong in colder, higher-elevation, low- to mid-order watersheds with lower road densities. Our results show that bull trout remain widely distributed and occur in most of the subbasins representing the potential range. Some strong and relatively secure populations exist. In general, bull trout are better represented in the region as a whole than many other native species. Important declines in distribution and status are evident, although the extent of change is clouded by uncertainties in the historical distribution. Despite the broad distribution, much of the current range is poorly represented by strong or protected populations. The southern margins of the range are a particular concern and could be an important priority for conservation management. Continued habitat loss associated with disruptive land use practices threatens remaining bull trout populations. Even with no further habitat loss, existing fragmentation could contribute to continuing local extinctions aggravated by the expansion of introduced species and the effects of climate change.

Codes: multi qual lulc

Rieman, B. E., and J. D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124: 285-296.

Bull trout Salvelinus confluentus and other salmonids in the Pacific Northwest are believed at risk of local and regional extinctions because of ongoing habitat loss and fragmentation. Biologists have focused on defining and protecting critical stream channel characteristics, but there is little information regarding the scale or spatial geometry of habitat that may be necessary for the species' long-term persistence. We investigated the influence of habitat patch size on the occurrence of bull trout by determining the presence or absence of fish in naturally fragmented watersheds of the Boise River basin in Idaho. We defined patches of potential habitat for bull trout as watersheds above 1,600 m elevation, a criterion based on the presumed restriction of local populations by stream temperature. We used logistic regression to investigate the possible influence of patch size as well as stream width and gradient on the occurrence of bull trout at reach, stream, and patch scales of analysis. Both stream width and patch size were significant in the models, but individual effects could not be clearly resolved because of collinearity. The predicted probability of occurrence based on patch size alone was less than 0.10 for patches smaller than about 1,000 ha and more than 0.50 for patches larger than about 2,500 ha. Our results support the hypothesis that area of available habitat influences the distribution of disjunct populations of bull trout. An area effect is consistent with the predictions of island biogeography and metapopulation theory, and our work suggests that larger-scale spatial processes may be important to the persistence of species like bull trout.

Codes: multi qual reach segment basin instream

Rieman, B. E., and J. D. McIntyre. 1996. Spatial and temporal variability in bull trout redd counts. North American Journal of Fisheries Management 16: 132-141.

We analyzed redd counts of bull trout Salvelinus confluentus in northern Idaho and northwestern Montana and found evidence of stronger correlation in the number and year-to-year change in number of redds between streams that were closer together than between streams that were far apart. The pattern was weak, however, indicating that spatial heterogeneity in habitat, in population demographics, or in life history at a local scale is important to stability of regional populations. The weak correlations also indicate that monitoring only a few index populations may not clearly represent the dynamics of larger regional populations. If synchrony is weak and not masked by sampling error, conservation management should favor the maintenance of high-quality habitats and strong local populations in proximity to each other to facilitate dispersal and demographic support. Common declining trends among all streams within a single lake basin show that even well-dispersed regional populations face important risks. Conservation management of species like bull trout must maintain populations at both local and regional scales.

Codes: multi basin segment spawn qual temporal

Riley, S. C., and K. D. Fausch. 1995. Trout population response to habitat enhancement in six northern Colorado streams. Canadian Journal of Fisheries and Aquatic Sciences 52: 34-53.

The effects were examined of log drop structures on trout populations in six small, remote Rocky Mountain streams. Angling pressure was low on all streams, and most anglers killed no fish. Log drop structures were installed in 250-m treatment sections in summer 1988, and results were compared with adjacent 250-m control sections during 1987-1990. The structures caused marked changes in habitat, including greatly increased pool volume, decreased current velocity, and increased depth and cover. After the structures were installed, abundance and biomass of age-2 and older trout (and often age-1 trout) increased in all six streams, but there was no evidence that trout were in better condition or grew to larger sizes in most streams. Recaptures of tagged trout in two streams showed that the logs did not result in increased growth or survival of resident trout, although recaptures of fin-clipped trout inother streams suggested that apparent survival may have increased temporarily in treatment sections.

Codes: multi experi reach quant migrat popdyn instream fishing

Rimmer, D. M. 1985. Effects of Reduced Discharge on Production and Distribution of Age-0 Rainbow Trout in Seminatural Channels. Transactions of the American Fisheries Society 114: 388-396.

The effects of reduced discharge on emigration, abundance, growth, production, and distribution of underyearling rainbow trout, Salmo gairdneri, were studied in small, seminatural experimental streams in New Zealand. Three stream channels had constant discharges of 0.125 cu m/s from mid-November (spring in southern hemisphere) to mid-February. Discharge was then reduced in two channels, but remained unchanged in the third. Reduction of discharge by 32% (to 0.085 cu m/s) and by 60% (to 0.050 cu m/s) caused no increase in downstream emigration, the emigration rate immediately before reduction being 0.1-0.7 fish/d and that for 5 months after reduction being 0.0-

0.3 fish/d. However, the results may have been influenced by unequal population sizes in the channels before the discharges were altered. Presumably, these differences were caused by unequal hatching success of eggs planted in the channel substrates. Population density was greatest (41/100 sq m) in the channel selected for control discharge. Following discharge alteration, this pattern continued (lowest discharge: 21/100 sq m; control: 7/100 sq m). Fish size differences between channels at the end of the experiment (7 July) were in direct relation to channel discharges and in inverse relation to population density (largest fish in the control and smallest fish in the low discharge channel). Reductions in instantaneous growth rates were attributable to reduced discharge, but occurred about 2 months after discharge reduction. Reduced discharge depressed production after about 1.5 months and by the end of the experiment there had developed a direct relationship between discharge and production; production was 1.4 g/100 sq m at 0.125 cu m/s and -3.8 g/100 sq m at 0.050 cu m/s. There were no significant differences among the channels in the distribution of fish among riffle, pool, and run habitat types. Before discharge reduction, fish in all channels occurred mostly in the riffles and, after reduction, fish in control and treated channels became progressively more evident in the pools. Discharge reduction had no effect on this distribution. (Author 's abstract).

Codes: experi reach quant popdyn migrat hydro

Rimmer, D. M., U. Paim, and R. L. Saunders. 1983. Autumnal habitat shift of juvenile Atlantic salmon (Salmo salar) in a small river. Canadian Journal of Fisheries and Aquatic Sciences 40: 671-680.

Autumnal changes in behavior and distribution of three age-classes of juvenile Atlantic salmon (Salmo salar) were determined during 3 yr in the Little Sevogle River of northeastern New Brunswick. In summer, salmon were always observed above the streambed, each holding a station over a single, unshaded stone. About 84% of the entire population occurred in the run habitat-type, 12% in riffles and 5% in pools. Underwater visual censuses showed the salmon to be continuously numerous in summer, but, as soon as water temperature fell to or below 10 degree C in autumn, they disappeared from their stations and their visible population decreased by 92-98%. Thereafter, the salmon were found almost exclusively in sheltered substrate chambers beneath surface streambed stones. However, salmon distribution among runs, riffles, and pools (77, 18, and 5%, respectively) did not differ significantly from that in summer. Trapping, marking, and absolute population estimates indicated neither dwindling nor egress of the resident population.

Codes: microhab habitat quant substrate temporal wtemp

Ringstad, N. R. 1974. Food competition between freshwater sculpins (genus Cottus) and juvenile coho salmon (Oncorhynchus kisutch): an experimental and ecological study in a British Columbia coastal stream. Report

A system of experimental troughs was designed to examine food competition between sculpins and juvenile coho. Manipulation of sculpin densities showed that sculpins at higher than stream densities were able to crop down the benthos sufficiently to significantly reduce drift densities and thus coho growth. At close to natural stream densities sculpins did not limit coho growth. A detailed study of the autecology of the 2 sculpins C. asper and C. aleuticus occurring in Carnation Creek did not alter this conclusion. Juveniles of both sculpin spp are found in the estuary. These results from either estuarine spawning or upstream spawning combined with downstream movement from March to July to the estuary, and subsequent metamorphosis of larvae. Upstream migration of young cottids takes place a year later from Aug to Dec. In the lower 1500 m of the stream C. asper tends to occupy areas with good cover and low current velocity, whereas C. leuticus is restricted to the peripheral areas of C. asper habitat and riffles. In the lowest reaches of the stream the ratio of C. aleuticus to C. asper is 4:1. Above 1500 m, in the absence of C. asper, C. aleuticus occupies all available habitat. C. aleuticus is smaller per age group than C. asper and the life span of both spp is up to 7 yr. Both spp are primarily bottom foragers feeding on aquatic insect larvae. Feeding increases throughout the night with maximal activity at or just before dawn. Some sexually mature adults of both spp undertake a downstream spawning migration in the spring. Most C. asper spawn in the estuary while C. aleuticus may undergo only local migrations and spawns primarily in freshwater.

Codes: experi reach qual sppinter trophic

Rinne, J. H. 1994. The effects of fire and its management on southwestern (USA) fishes and aquatic habitats. Lake and Reservoir Management 9: 108.

Based on case histories from 5 headwater streams on two National Forests in Arizona and New Mexico, the effects of naturally-caused wildfire on aquatic habitats, fishes and their food supply may be marked and long-lasting. Hydrologic events following recent (1989-1990) wildfires in Arizona and New Mexico effectively extirpated two population of brook trout (Salvelinus fontinalis), one of rainbow trout (Oncorhynchus mykiss) and one of Gila trout (O. gila). Aquatic macroinvertebrates densities effectively declined to zero within a month after the Dude Fire, and diversities 25 to 70% a year later. Trout re-introduced one year after the fire declined 85 to 97% in a two-year period. Suppression of fire in forests of the Southwest has resulted in increased fuel loading on watersheds and more large, hot, crowing wildfires. Removal of 60% of more of forest vegetation, extensive exposure of bare soil, and large accumulations of ash, followed by annual summer monsoon storms (July-September), result in flow events that have a high probability of totally removing a stream fish population and/or dramatically altering a potential food source, aquatic macroinvertebrates. #Abstract only.#.

Codes: multi experi reach quant lulc temporal ripar trophic

Rinne, J. N. 1982. Movement, home range, and growth of a rare southwestern trout in improved and unimproved habitats. North American Journal of Fisheries Management 2: 150-157.

Data collected on 129 recaptured Gila trout (Salmo gilae) in three streams on the Gila National Forest, New Mexico, indicated that this endangered trout tended to stay near "home" (mean movement < 0.1 km) and grew less, both in streams containing larger fish populations and streams containing log improvement structures, than in other streams. Those fish that moved went greater distances downstream. Few fish (< 2%) moved upstream over habitat-improvement structures, and such movement was limited by structures greater than or equal to 0.5 m high. In one intermittent stream, these fish oriented to permanent-water reaches. Future introductions of this rare trout should be in headwater areas, and habitat improvement should be done with a conservative number of low (0.5 m) structures.

Codes: multi reach quant migrat instream ripar

Rinne, J. N. 1988. Grazing effects on stream habitat and fishes: Research design considerations. North American Journal of Fisheries Management 8: 240-247.

A 4-year study of a montane stream from which cattle grazing had been excluded for 10 years indicated that stream bank vegetation and stability were markedly improved and that stream substrate fines were somewhat reduced, but it indicated that fish populations were unaffected. Shortcomings of this case history study are common to past similarly designed studies of grazing effects on fishes and their habitats. Three major deficiencies in research design are (1) lack of pretreatment data, (2) improper consideration of fishery management principles, and (3) linear positioning of treatments along a stream. Future research on riparian grazing effects must address these factors in addition to designs of long-term (10+ years) ecosystem (watershed) studies.

Codes: reach graz quant design

Rinne, J. N., and A. L. Medina. 1988. Factors influencing salmonid populations in six headwater streams, central Arizona, USA. Polskie Archiwum Hydrobiologii/Polish Archives of Hydrobiology 35: 515-535.

Comparison of abiotic and biotic variables that could influence trout populations in six headwater streams, central Arizona (USA) suggests that physical habitat strongly influences salmonid density and standing crop. Stepwise regression analysis indicated that stream depth explained most of the variation in density and biomass of trout (66 and 77%, respectively). Stream substrate explained 11 and 9% of the variation in trout density and biomass, respectively. Livestock grazing is suggested as a significant contributor to increased substrate fines (< 0.25) and reduced fish populations in several of these streams.

Codes: reach multi instream graz quant

Rodriguez, M. A. 1995. Habitat-specific estimates of competition in stream salmonids: A field test of the isodar model of habitat selection. Evolutionary Ecology 9: 169-184.

The population densities of sympatric Atlantic salmon, Salmo salar and brook charr, Salvelinus fontinalis, were measured in riffle and pool stream habitats to test whether non-linear isodars, a multispecific model of habitat selection based on ideal distribution assumptions, could (1) predict the distribution of densities between habitats and (2) reproduce the processes postulated to underlie spatial segregation and species interactions in previous laboratory and field studies. The model provided a good fit to observed density patterns and indicated that habitat suitability declined non-linearly with increased heterospecific competitor densities. Competitive effects in riffles appeared to be due to exploitative resource use, with salmon always emerging as the superior competitor. No evidence was found for interference competition in riffles. In contrast, interspecific competition in pools seemed to occur through exploitation and interference. The specific identity of the superior competitor in pools depended on the density of both species; pools provided the charr with refuge from competition with the salmon, presumably through the adoption by the charr of density-dependent behaviours, such as schooling and group foraging, that mitigated the negative impact of the salmon. Charr were displaced from the riffles toward the pools as the total salmon density increased. The isodar analysis, based on limited density data, successfully reproduced the processes suggested to underlie spatial segregation in previous field and laboratory studies and provided new insights into how changes in competitor densities modify habitat suitability in this system.

Codes: modeling habitat quant sppinter

Roni, P. 2001. Responses of fishes and salamanders to instream restoration efforts in western Oregon and Washington. Project Completion Report to Bureau of Land Management, Oregon State Office, 1515 S.W. 5th St. Portland OR 97208 and Environmental Conservation Division, Northwest Fisheries Science Center, NMFS, 2725 Montlake Blvd. E., Seattle WA 98112. , 132 p. January 2001.

#This report is really a comparative study in that he measures the density of organisms among structures in treated streams in comparison to densities in streams which have not been treated. He blocks his study design by essentially, gradient, bankfull width, channel type,confinement, and species composition. Essentially, the argument is that the experiment is done and he is merely collecting the results of the experiment (much like our study with Boone). The number of paired streams of treatment and reference reaches was 30. Each reach was about 100m long. The problem is like ours'. His measurements are snap-shot of densities, albiet once in summer and another during the winter. The dynamic aspects of population change are not covered. Mind you, this is a good study, but does not meet our strict criterion of following population change and yes putting large wood in streams appears to help juvenile salmonids.# (See Roni and Quinn (2001)).

Codes: multi experi reach quant instream lwd

Roni, P., T. J. Beechie, R. E. Bilby, F. E. Leonetti, M. M. Pollock, and G. R. Pess. 2002. A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds. NAJFM 22: 1-20.

Millions of dollars are spent annually on watershed restoration and stream habitat improvement in the U.S. Pacific Northwest in an effort to increase fish populations. It is generally accepted that watershed restoration should focus on restoring natural processes that create and maintain habitat rather than manipulating instream habitats. However, most process-based restoration is site-specific, that is, conducted on a short stream reach. To synthesize site-specific techniques into a process-based watershed restoration strategy, we reviewed the effectiveness of various restoration techniques at improving fish habitat and developed a hierarchical strategy for prioritizing them. The hierarchical strategy we present is based on three elements: (1) principles of watershed processes, (2) protecting existing high-quality habitats, and (3) current knowledge of the effectiveness of specific techniques. Initially, efforts should focus on protecting areas with intact processes and high-quality habitat. Following a watershed assessment, we recommend that restoration focus on reconnecting isolated high-quality fish habitats, such as instream or off-channel habitats made inaccessible by culverts or other artificial obstructions. Once the connectivity of habitats within a basin has been restored, efforts should focus on restoring hydrologic, geologic (sediment delivery and routing), and riparian processes through road decommissioning and maintenance, exclusion of livestock, and restoration of riparian areas. Instream habitat enhancement (e.g., additions of wood, boulders, or nutrients) should be employed after restoring natural processes or where short-term improvements in habitat are needed (e.g., habitat for endangered species). Finally, existing research and monitoring is inadequate for all the techniques we reviewed, and additional, comprehensive physical and biological evaluations of most watershed restoration methods are needed.

Codes: review multi basin reach offchann warnings

Roni, P., and T. P. Quinn. 2001. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. Canadian journal of fisheries and aquatic sciences/Journal canadien des sciences halieutiques et aquatiques. Ottawa ON [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 58: 282-292.

Thirty streams in western Oregon and Washington were sampled to determine the responses of juvenile salmonid populations to artificial large woody debris (LWD) placement. Total pool area, pool number, LWD loading and LWD forming pools were higher in treatment (LWD) placement. Total pool area, pool number, LWD loading, and LWD forming pools were higher in treatment (LWD placement) than paired reference reaches during summer or winter. Juvenile coho salmon (Oncorhynchus kisutch) densities were 1.8 and 3.2 times higher in treated reaches compared with reference reaches during summer and winter, respectively. The response (treatment minus reference) of coho density to LWD placement was correlated with the number of pieces of LWD forming pools during summer and total pool area during winter. Densities of Ag-+1 cutthroat trout (Oncorhynchus clarkii) and steelhead trout (Oncorhynchus mykiss) did not differ between treatment and reference reaches during summer but were 1.7 times higher in treatment reaches during winter. Age-1+ steelhead density response to treatment during summer was negatively correlated with increases in pool area. Trout fry densities did not differ between reaches, but the response of trout fry to treatment was negatively correlated with pool area during winter. Research indicates that LWD placement can lead to higher densities of juvenile coho during summer and winter and cutthroat and steelhead during winter.

Codes: multi experi reach quant instream lwd

Roper, B. B., D. L. Scarnecchia, and T. J. La Marr. 1994. Summer distribution of and habitat use by chinook salmon and steelhead within a major basin of the South Umpqua River, Oregon. Transactions of the American Fisheries Society 123: 298-308.

Snorkeling and established stream habitat assessment methods were used to determine basinwide summer habitat use by juvenile chinook salmon Oncorhynchus tshawytscha and juvenile steelhead O. mykiss in 1989 in eight reaches along 39 km of Jackson Creek, a fifth-order tributary to the South Umpqua River, Oregon. Juvenile steelhead (ages 0-3) were widely distributed throughout the entire stream but age-1 and older fish were found in higher densities in the middle reaches whereas age-0 fish were found in higher densities in the upper reaches. Juvenile chinook salmon were found in the highest densities in the middle reaches. Juvenile steelhead used mostly riffles in the downstream reaches but mostly pools in the upstream reaches. Age-0 chinook salmon were strongly associated with pools in all reaches. Several factors are suggested that may have influenced distribution and abundance of both species; these include high stream temperatures in the lower reaches, habitat preferences of each species, and the interaction and resultant habitat segregation between the two species. Densities of steelhead varied by nearly 5-fold over the reaches studied and densities of chinook salmon varied by more than 10-fold. Thus, habitat studies on streams with variable habitat and patchy fish distributions should be conducted over a larger area of the basin than has typically been the case in previous studies.

Codes: reach quant instream

Rosenfeld, J. 2000. Effects of fish predation in erosional and depositional habitats in a temperate stream. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa 57: 1369-1379.

Combined effects of predation by benthic and drift-foraging fish (prickly sculpin (Cottus asper) and coho salmon (Onchorhynchus kisutch parr) on benthic invertebrate community and trophic structure were evaluated in Mayfly Creek, a previously fishless stream in the Coast Range Mountains of British Columbia. The role of microhabitat in mediating predation effects was assessed by comparing invertebrate community structure on unglazed ceramic tiles and gravel baskets nested within enclosures. The role of macrohabitat was evaluated by placing enclosures in pool and riffle habitats. Effects of fish predation were most pronounced on tile substrate and in riffle habitat and least pronounced on gravel substrate in pool habitat. The presence of fish caused a decrease in abundance of larger bodied herbivores (primarily the mayflies Ameletus and Baetis) and had positive indirect effects on algae and smaller invertebrates (primarily Orthocladiinae chironomids and nemourid stoneflies), probably through competitive release. In contrast with herbivores, detritivorous invertebrates were less influenced by fish predation and more highly correlated with the abundance of organic detritus. The distribution and abundance of detritivores in Mayfly Creek appear to be primarily influenced by bottom-up forces, while grazers in algal-based food chains are more strongly influenced by top-down effects (fish predation).

Codes: reach sppinter trophic qual

Rosenfeld, J., M. Porter, and E. Parkinson. 2000. Habitat factors affecting the abundance and distribution of juvenile cutthroat trout (Oncorhynchus clarki) and coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 766-774.

The distribution, abundance, and habitat associations of juvenile anadromous coastal cutthroat trout (Oncorhynchus clarki) and coho salmon (Oncorhynchus kisutch) were evaluated using survey data from 119 sites in coastal British Columbia. Both cutthroat and coho occurred at their highest densities in very small streams (<5 m channel width), and bankfull channel width was the single best predictor of cutthroat presence ($p = 0.0001$) and density (R super(2) = 0.55). Within a channel, densities of coho and larger (yearling and older) cutthroat parr were highest in pools, while densities of young-of-the-year cutthroat were significantly lower in pools and highest in shallower habitats. Abundance of larger cutthroat parr and pool habitat were positively correlated with large woody debris (LWD) within a subset of intermediate-gradient gravel-cobble streams, where pools appear to be limiting to larger cutthroat parr abundance. More than 50% of pools were formed by scour associated with LWD in streams ranging from 1.2 to 11 m channel width, and pools formed by LWD scour were on average 10% deeper than pools formed by other mechanisms. Disproportionate use of small streams by cutthroat indicates that protection of small stream habitat is important for long-term conservation of sea-run populations.

Codes: multi reach quant instream lwd substrate

Roussel, J. M., and A. Bardonnet. 1999. Ontogeny of diel pattern of stream-margin habitat use by emerging brown trout, Salmo trutta, in experimental channels: influence of food and predator presence. Environmental Biology of Fishes 56: 253-262.

Age-0 brown trout, Salmo trutta, inhabit shallow and slow-flowing habitats where they can easily maintain stationary swimming positions. However, recent results have shown that they use deeper and faster habitats during daylight than at night, suggesting the occurrence of a nocturnal movement toward stream-margin habitats.

Experiments were conducted to describe precisely when this diel pattern of habitat use appears during ontogeny. In two indoor channels, free-embryo brown trout were deposited under the gravel. When emerging, alevins were free to choose between margin (2 cm deep, 0-2 cm s super(-1)) or deep habitat (12 cm, 2-4 cm s super(-1)), or to leave the channel (upstream or downstream). During the week of emergence, upstream and downstream catches, fish habitat use (deep habitat or margin), and fish behavior (resting or swimming) were measured by direct observations and trap counts. Three treatments were performed: (1) fish artifically fed on drifting invertebrates, (2) fish exposed to predators (bullhead, Cottus gobio), and (3) control channels (no food, no predator). In control and food channels, a diel pattern of habitat use was observed 1-2 days after the emergence started. Most fish rested in the margin at night, whereas they moved towards the deep habitat during daylight to hold stationary swimming positions. In the presence of bullhead, most trout were cryptic, and visible fish stood in the margin during both daylight and at night. The importance of predation risk and foraging behavior on the ontogeny of the diel pattern of habitat use is discussed. Results support the direct development without larva from free-embryo via alevin in brown trout.

Codes: experi habitat qual trophic

Roussel, J. M., A. Bardonnet, J. Haury, J. L. Bagliniere, and E. Prevost. 1998. Aquatic plants and fish assemblage: a macrophyte removal experiment in stream riffle habitats in a lowland salmonid river (Brittany, France). Edited by P. Prunet, J. L. Bagliniere, B. Breton, O. Kah, F. Pakdel and P. Saglio. Conseil Superieur de la Peche, Boves (France)

The effect of aquatic weed development on fish habitat preferences was studied during a two-year in situ experiment in lotic habitats of the Scorff river (Brittany, France). In the two riffles studied (800 and 600 M super(2) macrophytes (essentially Ranunculus penicillatus) covered more than 70% of the total surface area during the growing season in spring. In May, macrophytes were removed from one stream bank to the center of the riverbed (in each riffle) in order to create habitat without aquatic vegetation. The main effect of macrophyte removal on the physical habitat variables was an increase in water velocity (60% on average). One month later, electrofishing surveys showed greater fish biomass and higher densities in vegetated habitats. The same species were present in both habitat types but density in Atlantic salmon parr (Salmo salar L.) was higher in habitats without macrophytes (30 ind times 100 m super(-2) on average) than in vegetated habitats (15 ind times 100 m super(-2) on average). Conversely, stone loach (Barbatula barbatula L.) and European minnow (Phoxinus phoxinus L.) densities were 47 ind times 100 m super(-2) on average in vegetated habitats, i.e. two to four times greater than in habitats without vegetation. The results point out that macrophytes can change drastically habitat conditions and suggest a decrease in the carrying capacity of riffles for age-0 salmon parr.

Codes: experi habitat quant instream

Sabaton, C., L. Siegler, V. Gouraud, J. L. Bagliniere, and S. Manne. 1997. Presentation and first applications of a dynamic population model for brown trout, Salmo trutta L.: Aid to river management. Fisheries Management and Ecology [Fish. Manage. Ecol.] 4: 425-438.

A mathematical model representing the long-term change in a trout population under different river management scenarios is presented. It describes the structure of a population broken down into age classes based on the Leslie matrix; if the population structure for any given month is known, the model should be able to estimate that of the following month. The passage from one month to the next takes into account various relevant factors: survival rate of individuals in the different age classes; fertility rate of females; linear and weighted growth rates; displacement linked to habitat fluctuations using weighted usable area (WUA) values. The model was applied to two French rivers. Regular monitoring of trout populations on the River Kernec enabled comparison of the response of the model with no displacement, with actual variations in fish stocks on the first river. In addition, the knowledge of WUA chronologies on the River Echez made it possible to carry out initial simulations of the response of a fish population to different river management scenarios at the second site.

Codes: modeling popdyn habitat ifim temporal hem

Saffel, P. D., and D. L. Scarnecchia. 1995. Habitat use by juvenile bull trout in belt-series geology watersheds of northern Idaho. Northwest Science 69: 304-317.

Bull trout (Salvelinus confluentus), a native char of the Pacific Northwest, has declined in abundance and distribution in recent years. Little is known about the habitat use by salmonids in streams with substrate characterized by Belt-Series geology. Such information could be used by managers to evaluate potential effects of land use practices on the species, or to enhance or protect existing habitat. A total of 28 pools, 60 riffles, and 46 runs was sampled in 14 reaches of four streams to determine habitat use of age 0 and age greater than or equal to 1 juvenile bull trout in three habitat types (pools, runs, and riffles) and in channel margins and main channels. Age 0 bull trout used habitat types in equal proportion to availability, whereas age greater than or equal to 1 juvenile bull trout selected pools and avoided riffles. Lateral position within the stream channel differed with age class: 88% of the age 0 fish were in the channel margins, whereas 91% of the age greater than or equal to 1 fish were in the main channel. In addition to the habitat use study, 18 reaches in six streams were studied to determine habitat characteristics that influence abundance and distribution of juvenile bull trout. Reaches with high densities (3.9 to 11.2 fish/100 m super(2)) of bull trout had maximum summer temperatures ranging from 7.8 to 13.9 degree C, whereas most reaches with low densities (<1.0 fish/100 m super(2)) had higher maximum summer temperatures (18.3 to 23.3 degree C). Density of juveniles in reaches increased with the number of pocket pools/100 m. The combination of number of pocket pools and maximum summer temperature explained nearly two-thirds of the variation in density of juvenile bull trout.

Codes: multi reach habitat quant instream wtemp

Sale, M. J., J. M. Loar, G. F. Cada, and P. Kanciruk. 1983. Applicability of the instream flow incremental methodology (IFIM) for predicting trout biomass and abundance. EOS, Transactions, American Geophysical Union 64: 702.

An evaluation of the IFIM physical habitat model (U.S. Fish and Wildlife Service) is being carried out in trout streams in the southern Appalachian mountains. This study will provide guidance for regulators and developers on the assessment for instream flow needs at hydroelectric projects. Eight sites with naturally reproducing populations of brown trout (Salmo trutta) and/or rainbow trout (S. gairdneri) and with minimal disturbances from water pollution, stocking, and excessive fishing pressure were selected for study in Tennessee and North Carolina. Weighted usable area (a measure of physical habitat condition), water quality, benthic invertebrate biomass, fish standing crop, and fish production were estimated at each site over an eighteen-month period. A multivariate statistical approach was used to determine the best predictors or fish biomass and abundance.

Codes: multi reach quant instream watqual ifim hem

Sankovich, P., R. W. Carmichael, and M. L. Keefe. 1998. Fish research project - Oregon: Smolt migration characteristics and mainstem Snake and Columbia River detection rates of PIT-tagged Grande Ronde and Imnaha River naturally-produced spring chinook salmon. Annual report 1996.

This is the fifth year of a multi-year study to assess smolt migration characteristics and cumulative detection rates of naturally-produced chinook salmon (Oncorhynchus tshawytscha), from northeast Oregon streams. The goal of this project is to develop an understanding of interpopulation and interannual variation in several early life history characteristics of naturally-produced chinook salmon from the Grande Ronde and Imnaha River subbasins. This project provides information useful in the recovery of listed Snake River spring/summer chinook salmon. Specific populations included in the study are (1) Catherine Creek, (2) upper Grande Ronde River, (3) Lostine River, (4) Imnaha River, (5) Wenaha River, and (6) Minam River. In this document, we present findings from research completed in 1996. Naturally-produced chinook salmon populations in the Grande Ronde and Imnaha River subbasins have declined drastically in recent years due in part to habitat alterations and hydropower development. Declines have continued despite extensive mitigation efforts, including fish passage improvements, artificial production, supplementation, and habitat modification (BPA Division of Fish and Wildlife 1990). Snake River spring/summer chinook salmon (hereafter referred to as chinook salmon), which include naturally-produced chinook salmon in the Grande Ronde and Imnaha River subbasins, have been listed under the Endangered Species Act of 1973 as threatened or endangered since 1992.

Codes: multi reach basin migrat instream temporal

Scarnecchia, D. L., and E. P. Bergersen. 1986. Production and habitat of threatened greenback and Colorado River cutthroat trouts in Rocky Mountain headwater streams. Transactions of the American Fisheries Society 115: 382-391.

Field studies conducted in 1979 and 1980 to assess the production and habitat of cutthroat trouts Salmo clarki in three headwater tributaries in north-central Colorado yielded the following estimates of production (g/m2): greenback cutthroat trout S. c. stomias in Roaring Creek, 3.3 in 1959 and 2.3 in 1980; greenback cutthroat trout in the Right Hand Fork of Roaring Creek, 3.6 in 1979 and 1.5 in 1980; Colorado River cutthroat trout S. c. pleuriticus in Little Green Creek, 2.2 in 1979 and 3.6 in 1980. Biomass and production in Roaring Creek and Right Hand Fork of Roaring Creek were dominated by old („3 years) slow-growing fish. Little Green Creek was the warmest and slowest moving of the creeks studied and had a low diversity of substrates dominated by fine and coarse gravel--it also had the highest biomass and production of young of the year. Right Hand Fork Roaring Creek had faster flows and more extensive undercut banks--it also had the most large fish („152 mm long). Biomass and production of cutthroat trout within the three streams depended mainly on stream-specific physical characteristics. In addition, year-class strength appeared to be mainly affected by the time of emergence and growth rates of juveniles prior to their first winter and by the abundance of large resident fish.

Codes: multi reach quant popdyn instream substrate

Scarnecchia, D. L., and E. P. Bergersen. 1987. Trout Production and Standing Crop in Colorado 's Small Streams, as Related to Environmental Features. North American Journal of Fisheries Management 7: 315-330.

Annual production of trout (Salvelinus and Salmo spp.) in 10 small northern Colorado streams ranged from 1.5 to 18.4 g/sq m in 1979 and 1980. Midsummer biomass ranged from 3.9 to 28.2 g/sq m. Ratios of production to biomass ranged from 0.23 to 0.95. Fish production and biomass were related inversely to elevation and directly to substrate diversity, conductivity, alkalinity, and water hardness. Combinations of the various factors explained much of the variation in production: elevation and width:depth ratio, 60%; elevation and substrate diversity, 54%; elevation, substrate diversity, and percentage of zero-water-velocity stations, 79%; and elevation, width:depth ratio, and alkalinity, 77%. Similar relationships were developed for midsummer biomass. There was a strong correlation between midsummer biomass and annual production as well as between annual production and the density of fish of desirable size (152 mm long or longer) in each stream. Several relationships are proposed from these data sets that can be used to predict trout production in small, high-elevation streams. Estimated habitat quality indices for the 11 sections were significantly related to midsummer biomass of trout in 1979 but not in 1980. (Author 's abstract).

Codes: multi reach quant instream watqual substrate

Scarnecchia, D. L., and B. B. Roper. 2000. Large-scale, differential summer habitat use of three anadromous salmonids in a large river basin in Oregon, USA. Fisheries Management and Ecology 7: 197-209.

Codes: multi reach quant? instream

Scherer, E., R. E. McNicol, and E. J. Murkin. 1984. Observations on habitat selection and partitioning by brook charr, Salvelinus fontinalis (Mitchill), in the South Duck River, a Manitoba woodland stream. Report ISSN 0706-6473.

The South Duck River is a spring-fed woodland stream in west-central Manitoba, containing a population of brook charr, S. fontinalis, but no other salmonid species. This report presents results of a preliminary survey on habitat selection and partitioning by this species within a 168 m long stream section, in relation to current velocity, substrate, and depth. A distinct separation of habitats for young-of-the-year and older year-classes was apparent. Young-of-the-year preferred shallow (approximately equals 10-20 cm deep), moderately fast-flowing (10-20 cm multiplied by s super(-1)), gravel and rubble covered areas, while older year-classes were found in deeper areas (20-85 cm deep), with a wider range of current velocities and substrates, including areas covered with sand and silt.

Codes: habitat qual? instream substrate

Schneider, J. 1998. Habitat choice in juvenile Atlantic salmon (Salmo salar Linne, 1758) at selected releasing spots in the Rhineland-Palatinate. Zeitschrift Fuer Fischkunde 5: 77-100.

The daytime habitat choice of 355 juvenile (0+ and 1+) Atlantic salmon (Salmo salar) parr was examined in second and third order streams in the Rhineland-Palatinate state (Germany) by electrofishing using the point abundance method. The study is part of the "Salmon 2000" program intended to reintroduce Atlantic salmon to the river Rhine where they were extirpated in the middle of the century. The stream locations salmon parrs inhabited were classified as riffle-pool, deep pool, low current and standing water habitats. Association to cover by salmon parr was determined by measuring different cover structures such as submerse vegetation /roots, overhanging structures and rocks at the micro-scale of salmon position (focal point). Furthermore individual substrate choice was recorded. Finally, physical factors such as water depth, water velocity, broken water surface, shade and distance from the shore were also assessed at the focal point of salmon. Competition was studied by recording the number of salmonids (salmon and brown trout (Salmo trutta) captured at the same location. Results were analysed separately for (1) young-of-the-year (age 0+) < 100 mm standard length (n1 = 200) and (2) 1+ parrs (n2= 155) measuring > 100 mm SL. Large salmon parrs preferred deeper locations (e.g. deep pools), low velocities and a low percentage of gravel. Small salmon inhabited mainly riffles with variable velocities and avoided deep pools. The results will help to determine habitat suitability for successful re-introduction of the species.

Codes: multi microhab qual instream foreign

Scott, J. B., C. R. Steward, and Q. J. Stober. 1986. Effects of urban development of fish population dynamics in Kelsey Creek, Washington. Transactions of the American Fisheries Society 115: 555-567.

A 30-mo study of the comparative dynamics of the fish populations inhabiting Kelsey Creek, located in the City of Bellevue, Washington, and a nearby pristine control stream suggest that urban development has resulted in a restructuring of the fish community. Environmental perturbations, including habitat alteration, increased nutrient loading, and degradation of the intragravel environment appeared to have a greater impact on coho salmon Oncorhynchus kisutch and nonsalmonid fish species than on cutthroat trout Salmo clarki. Although the total biomass (g/m super(2)) of fish in each stream was similar, its composition differed markedly. Ages 0 and I cutthroat trout were the majority of the fish community inhabiting Kelsey Creek, whereas the control stream supported a diverse assemblage of salmonids of various ages and numerous non-salmonids.

Codes: experi reach quant instream watqual substrate

Scrivener, J. C., and B. C. Andersen. 1984. Logging impacts and some mechanisms that determine the size of spring and summer populations of coho salmon fry (Oncorhynchus kisutch) in Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 41: 1097-1105.

Natural patterns in emergence times, seaward movements, instream distributions, densities, and growth of coho salmon fry (Oncorhynchus kisutch) between March and September are contrasted with patterns observed during and fate logging in the Carnation Creek watershed. After streamside logging in 1976-77, fry emerged up to 6 wk earlier and moved seaward more quickly than during years before logging. These observations are attributed to higher water temperatures during the winter and to emergence during a period of more frequent freshets. Increased fry movement from the stream could result in habitat being underutilized. In sections affected by intense streamside logging, the deposition of "fine" logging debris led to increased fry densities during the summers of 1977 and 1978.

Codes: experi reach quant migrat ripar wtemp

Scruton, D. 1996. Evaluation of the construction of artificial fluvial salmonid habitat in a habitat compensation project, Newfoundland, Canada. Regulated Rivers Research & Management 12: 171-183.

In 1987, the provincial transportation agency in Newfoundland, Canada requested approval from the Canadian Department of Fisheries and Oceans (DFO) to destroy a 162 m section of fluvial salmonid habitat to accommodate highway construction. The DFO's Policy for the Management of Fish Habitat required the proponent to compensate for this habitat loss through the construction of a replacement section of stream. The results are presented from a research programme to evaluate the success of this project focusing on: (1) considerations in the design and construction of the replacement habitat; (2) a comparison of key habitat attributes between the destroyed stream section and the compensatory habitat; and (3) the utilization of the compensatory habitat by resident fish. The results of the study indicate an increase in habitat area of 125 m super(2) (23%) over the 162 m section of stream habitat lost due to construction, primarily related to the increase in thalweig length (20% increase) resulting from designed sinuosity in the compensatory habitat. Habitat design increased the amount and proportion of pool habitat to benefit the primary resident species, brook trout (Salvelinus fontinalis) and resulted in a 134% increase in pool quantity (increase of 98 m super(2)), a 281% increase in pool volume (31.06 m super(3)), a 223% increase in the pool to riffle ratio and a 29% increase in the mean depth. Fish biomass, after an initial decrease after construction (1991), increased to the highest level during the study (93.5 g per 100 m super(2) unit) in 1993, a 2.1-fold increase over the average pre-construction biomass. A corresponding decrease in salmonid densities was evident, primarily reflecting a shift in use from young of the year (YOY or 0+) Atlantic salmon (Salmo salar) to larger, older brook trout in response to desired habitat features. Using biomass as an indicator of 'productive capacity' and considering the increase in habitat quantity, there was a 2.58-fold increase in productive capacity over the stream lost due to highway construction and, in the context of DFO's habitat policy, compensation has resulted in a 'net gain' in habitat.

Codes: experi reach quant instream

Scruton, D. A., K. D. Clarke, T. C. Anderson, A. S. Hoddinott, M. C. Van Zyll De Jong, and K. A. Houston. 1997. Evaluation of habitat improvement and restoration initiatives for salmonids in Newfoundland, Canada. Canadian manuscript report of fisheries and aquatic sciences/Rapport manuscrit canadien des sciences halieutiques et aquatiques. Imprint varies [CAN. MANUSCR. REP. FISH. AQUAT. SCI./RAPP. MANUSCR. CAN. SCI. HALIEUT. AQUAT.], Mar 40:

Declining Atlantic salmon Salmo salar stocks, which forced the closure of the commercial salmon fishery in Newfoundland in 1992, coupled with the increasing economic importance of the recreational salmonid fishery, has resulted in two major federal-provincial agreements over the past decade aimed at rebuilding the salmonid stocks. These agreements included habitat improvement and restoration as a major strategy and supported 142 projects. It was recognized that a proportion of these projects should undergo scientific evaluation to provide information on the effectiveness and transferability of techniques and to assist in developing region-specific criteria to guide publicly sponsored habitat initiatives. This report provides an overview of these evaluations, as selected case studies, including projects involving restoration of habitat degraded by historic forest harvesting, removal of a natural migration barrier, and the addition of spawning gravel to increase juvenile production. Results of a series of experimnents in a controlled flow channel to investigate the effect of several habitat alterations on salmonid populations under Newfoundlan conditions are discussed. Generally, the projects evaluated have been successful in increasing salmonid abundance and/or production. Results highlight the importance of hydrological and biological considerations to habitat improvement and restoration initiatives.

Codes: review experi enclos reach quant

Scruton, D. A., and L. J. Ledrew. 1997. A retrospective assessment of the flow regulation of the West Salmon River, Newfoundland, Canada. Fisheries Management and Ecology [Fish. Manage. Ecol.] 4: 467-480.

The Upper Salmon Hydroelectric Project in central Newfoundland, Canada, constructed in the early 1980s, affected the hydrology of the West Salmon River, a major spawning and juvenile rearing river for landlocked Atlantic salmon, Salmo salar L., and brook trout, Salvelinus fontinalis (Mitchill). A controlled flow release strategy, based on Tennant's Montana method, was developed to protect this habitat and prescribed a release of 40% of the mean annual flow (MAF) (2.6 m super(3) s super(-1)) between 1 June and 30 November and 20% of the MAF (1.3 m super(3) s super(-1)) from 1 December to 31 May. Studies were conducted to assess the impact of river regulation including: (1) a post-impoundment evaluation of the anticipated geomorphic and sedimentary characteristics; (2) monitoring of juvenile fish populations under regulation; and (3) a retrospective IFIM (instream flow incremental methodology) assessment. Studies provided evidence of the initial stages of river aggradation. Biological monitoring found no apparent effects of sediment deposition on spawning and egg incubation. However, densities of older age classes (parr, 1+ and greater) declined under regulation, possibly related to poor overwintering conditions under the lower winter flow. IFIM study results supported these observations and indicated that the prescribed flow regimen provided habitat conditions that would benefit salmon fry more than older age classes. This retrospective assessment suggested that future proposals for flow regulation in Newfoundland should consider the need for more dynamic flow management as well as to provide overwintering habitat for resident fish. Habitat-hydraulic models are preferred to standard setting approaches owing to more detailed analysis of habitat trade-offs as related to flow regulation.

Codes: reach quant spawn lakehydro instream substrate ifim hem temporal

Shepard, B. B. 1989. Evaluation of the U.S. Forest Service ' COWFISH ' Model for Assessing Livestock Impacts on Fisheries in the Beaverhead National Forest, Montana. Pages 23-33. Practical Approaches to Riparian Resource Management: An Educational Workshop. American Fisheries Society, Bethesda MD.

The COWFISH fish habitat model developed by the U.S. Forest Service was evaluated during 1986 and 1987 at 43 stream sites within the Beaverhead National Forest, Montana to determine the ability of the model to assess effects of livestock grazing on trout fisheries. The COWFISH model uses a field survey of five variables (percentage of streambank with overhanging vegetation, percentage embeddedness, percentage of the streambank undercut, percentage of the streambank in an altered condition, and width:depth ratio) in association with channel gradient and the presence or absence of granitic parent material within the drainage to predict optimum and existing numbers of catchable (152 mm total length and longer) trout. The model predicted reasonable estimates of catchable cutthroat trout Oncorhynchus clarki, rainbow trout O. mykiss, and hybrids of these species at 19 sites where one or more of these forms occurred; however, predicted numbers of catchable brook trout Salvelinum fontinalis were imprecise at the 26 sites containing brook trout. Habitat suitability index results for field data collected by different observers did not appear to be significantly different, and results for sites that deviated from model site criteria were not significantly different from sites that met site criteria. Minor modifications in the model appeared to slightly improve model performance. Use of the COWFISH model by range professionals and livestock permittees did increase their awareness of the effects of livestock grazing on aquatic resources. (See also W90-05491) (Author 's abstract).

Codes: reach multi graz instream quant hsi modeling hem

Shepherd, B. G., J. E. Hillaby, and R. J. Hutton. 1986. Studies on Pacific salmon (Oncorhynchus spp.) in Phase 1 of the Salmon Enhancement Program. Volume 2: Data appendices. Report ISSN 0706-6457. database.

From 1977 to 1984 the New Projects Unit initiated 38 field studies on wild salmon stocks throughout British Columbia, in order to develop biological design criteria for proposed enhancement projects. The purpose of this report is to make the data from these studies more easily available to other users. Data are presented on migration timing, distribution and abundance of adults and juveniles; spawner characteristics; and length, weight and condition factors of juveniles. Physical characteristics of stream habitat important for spawning and rearing of wild salmon are also reviewed. These data are tabulated by stream and stock in Volume II; Volume I overviews the information by species and region, and provides perspective on factors which may have affected the findings.

Codes: database

Shepherd, B. G., J. E. Hillaby, and R. J. Hutton. 1986. Studies on Pacific salmon (Oncorhynchus spp.) in Phase 1 of the Salmonid Enhancement Program. Volume 1: Summary. Report ISSN 0706-6457. database.

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Codes: database

Sheppard, J. D., and J. H. Johnson. 1985. Probability-of-use for depth, velocity, and substrate by subyearling coho salmon and steelhead in Lake Ontario tributary streams. North American Journal of Fisheries Management 5: 277-282.

Probability-of-use information for depth, velocity, and substrate by subyearling coho salmon (Ohcorhynchus kisutch) and steelhead (Salmo gairdneri) in three New York tributaries of Lake Ontario was obtained during June and October in 1980. In June, coho salmon occurred predominantly in areas with mean velocities of 0.30-0.70 ft/second and at depths of 2.00-2.40 ft, whereas steelhead occupied habitats with mean velocities of 0.40-0.80 ft/second and depths of 0.30-0.50 ft. In October, subyearling coho salmon were found in areas with mean velocities of 0.00-0.30 ft/second and at depths of 1.50-2.80 ft while steelhead occurred at depths of 0.60-1.20 ft where mean velocities were 0.10-0.80 ft/second. Subyearling coho salmon occurred over gravel-cobble substrates during both seasons, whereas steelhead were found in areas with substrate material of larger sizes in the autumn. Observed seasonal differences in the habitat and flow preferences of both species were completely masked when the data were pooled to yield a single estimate for depth and mean velocity. Variations in the probability-of-use for these habitat parameters may be related to seasonal differences in fish size and the physical characteristics of the streams.

Codes: multi qual microhab habitat instream

Shirvell, C. S. 1989. Ability of PHABSIM to predict chinook salmon spawning habitat. Regulated Rivers: Research & Management 3: 277-289.

PHABSIM (Physical HABitat SIMulation), part of the Instream Flow Incremental Methodology, was used to predict the spawning habitat used by chinook salmon (Oncorhynchus tshawytscha) in a 600 m long section of the

Nechako River, British Columbia, Canada. Predictions of the model were compared to the location and amount of habitat actually used by adult chinook salmon. About 70% of the spawning area actually used by the population was predicted as unusable by the "best" prediction, while 87% of the area predicted as usable has never had recorded use. PHABSIM predicted 210% to 660% more spawning habitat was available than historically had ever been used. Chinook salmon in the Nechako River spawn mainly on the upstream face of dunes, therefore, the assumption in PHABSIM that conditions predicted at the transects remain unchanged upstream and downstream part way to the adjacent transects was false. About two-thirds of the correct predictions being made for the wrong reason. The accuracy of PHABSIM's predictions for spawning might be improved by incorporating an index of river bottom topography or velocity gradient into the model.

Codes: qual hydro microhab instream ifim warning hem

Shirvell, C. S. 1994. Effect of changes in streamflow on the microhabitat use and movements of sympatric juvenile coho salmon (Oncorhynchus kisutch) and chinook salmon (O. tshawytscha) in a natural stream. Canadian Journal of Fisheries and Aquatic Sciences 51: 1644-1652.

Changes in river discharge (referred to as "streamflow" herein) associated with flow regulation can have negative effects on fish and wildlife resources. The microhabitats at positions selected by juvenile coho (Oncorhynchus kisutch) and chinook salmon (O. tshawytscha) following a change in streamflow differed from microhabitats occupied at normal streamflows. At drought streamflow (37% mean seasonal streamflow (MSF)), juvenile coho salmon selected slower, darker, and higher sites above the streambed ($P < 0.05$) than sites selected at normal (75% MSF) or flood (159% MSF) flows. Juvenile chinook salmon microhabitat use changed similarly with changes in streamflow, but the difference were not significant. Up to one fifth of the fish chose positions with faster water velocities than those available either 30 cm above or 30 cm lateral to them. These fish chose positions inconsistent with the hypothesis of optimal position selection based on maximizing net energy gain. On average, fish moved 6.8 m following a change in streamflow. Juvenile coho salmon generally moved upstream in response to decreasing streamflows and downstream in response to increasing streamflows. Juvenile chinook salmon tended to move offshore and downstream in response to all streamflow changes.

Codes: qual hydro microhab instream

Shirvell, C. S., and R. G. Dungey. 1983. Microhabitats chosen by brown trout for feeding and spawning in rivers. Transactions of the American Fisheries Society 112: 355-367.

This study's objective was to quantify the water depth, water velocity, and substrate used by adult brown trout Salmo trutta for feeding and spawning in rivers. Brown trout (mean fork length 42 cm) preferred a mean depth of 65.0 cm and a mean velocity of 26.7 cm multiplied by second super(-1) at the position occupied by the fish for feeding, but for spawning they preferred a mean depth of 31.7 cm, a mean velocity of 39.4 cm multiplied by second super(-1), and a mean substrate size of 14.0 mm. Analysis of variance showed brown trout preferred the same velocity for the same activity in all rivers and years regardless of whether they were from allopatric or sympatric populations, but microhabitats used for feeding and spawning were significantly different. Velocity appeared to be the most important factor determining position choice but ranking of factors may vary with the type of activity. Brown trout chose positions with optimum combinations of depth and velocity instead of positions with more preferred values of either factor alone. Population size may be limited by the amount of the least abundant activity-specific microhabitat.

Codes: qual spawn microhab instream substrate

Shuler, S. W., and R. B. Nehring. 1993. Using the physical habitat simulation model toevaluate a stream habitat enhancement project. Rivers 4: 175-193.

Adult and juvenile brown trout (Salmo trutta) habitat suitability criteria (HSC) curves developed in the Rio Grande and South Platte rivers, Colorado, were used in the Physical Habitat Simulation (PHABSIM) model to evaluate habitat (weighted usable area; WUA) created by enhancement structures in the Rio Grande River. Although HSC curves for the two rivers produced slightly different estimates of WUA at a single study site and flow, WUA relations among study sites were similar over a wide range of flows. For both HSC curve sets, adult trout WUA and density were positively correlated across 10 study sections in each of 3 years (1989 through 1991). Beyond age-3, the significance level increased with age. Correlations of juvenile brown trout density and WUA were not significant. Composite suitability indexes (water depth, velocity, and cover) for individual cells were stratified into optimal, acceptable, and unsuitable habitat ranges. Observation by snorkeling and angling revealed that adult and juvenile trout preferred optimal and acceptable habitat zones and avoided unsuitable habitat during day and night across a range of flows. Habitat quality and quantity differed among structures over a range of flows. In riffle areas, greater levels of habitat enhancement increased preferred habitat availability according to the PHABSIM model. Moreover, densities of trout greater than or equal to 35 cm increased significantly after the placement of habitat enhancement structures.

Codes: qual instream microhab ifim hem

Simondet, J. A. 1997. Seasonal and diel response to habitat complexity by an allopatric population of coastal cutthroat trout. Edited by J. D. Hall, P. A. Bisson and R. E. Gresswell. American Fisheries Society, Oregon Chapter, Corvallis, Oregon (USA)

In contrast to salmonids in other systems, density of cutthroat trout in Little Jones Creek, a tributary of the Middle Fork Smith River, California, is not significantly related to the presence of large woody debris. The cutthroat trout is the only fish species in Little Jones Creek. In this study, I tested the relationship between cutthroat trout density and habitat complexity in a field experiment that used pools as experimental units. By adding a variety of structures, I enhanced the complexity of 6 of 12 pools that initially contained no large substrate elements and few microhabitats that provided cover for fish. I then removed pool inhabitants from each experimental unit, and added fish from elsewhere in the study reach to approximately double natural fish densities. I observed fish over 6 weeks in summer and 4 weeks in winter, during day and night. Cutthroat trout did not respond to differences in habitat complexity. In both summer and winter, fish densities rapidly returned to natural levels in both enhanced and control pools. During summer, approximately equal numbers of fish were observed during day and night, but during winter approximately 2.5 times more fish were observed at night than in the day. In Little Jones Creek, in the absence of competition from other fishes, simple and complex pools appear similarly valuable to cutthroat trout.

Codes: experi habitat quant instream lwd

Simpkins, D. G., W. A. Hubert, and T. A. Wesche. 2000. Effects of Fall-to-Winter Changes in Habitat and Frazil Ice on the Movements and Habitat Use of Juvenile Rainbow Trout in a Wyoming Tailwater. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 129: 101-118.

Overwinter declines in the abundance of small rainbow trout Oncorhynchus mykiss have been observed in a section of the Big Horn River that lies downstream from Boysen Reservoir, where reservoir releases prevent surface ice formation. To provide insight into the possible causes of these declines in abundance, radiotelemetry was used to determine movement and microhabitat use of juvenile (20-25 cm total length) rainbow trout during the fall and winter of 1995-1996. Throughout the fall and winter, both stocked (hatchery) and naturallyspawned (wild) fish were generally found in main-channel pools with cover that reduced current velocities to less than 2 cm/s near the bottom and with nearby (<2 m) water velocities that were greater than 15 cm/s. These locations provided refuges from the current, with adjacent flowing water that could deliver drifting aquatic invertebrates. The fish were generally associated with cover that was formed by aquatic vegetation early in the fall, but they shifted to cobble and boulder cover (in deeper water) as the aquatic vegetation decomposed and as winter progressed. Episodes of frazil ice in

January and early February were associated with movements of wild fish in the upstream portion of the study area--from normal activity areas to refuges at the bottom of deep pools or under shelf ice in shallow water near shore. Frazil-ice episodes often initiated long-term movements among fish. Our results suggest that changing habitat features from fall to winter and frazil-ice episodes can cause juvenile rainbow trout to move and to modify their habitat use, depending on their location in a tailwater.

Codes: migrat qual microhab instream substrate hydro

Slaney, T. L., K. D. Hyatt, T. G. Northcote, and R. J. Fielden. 1996. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries 21: 20-32.

Using fisheries agency databases and files, we assembled a summary database on the status of anadromous salmon stocks (genus Oncorhynchus) from British Columbia and Yukon streams. We then collected supplementary information by circulating the database among fisheries professionals and interest groups throughout British Columbia and thus identified 9,662 anadromous salmon stocks. These stocks included 866 chinook, 1,625 chum, 2,594 coho, 2,169 pink, 917 sockeye, 867 steelhead and 612 sea-run cutthroat trout stocks. We assessed the status of anadromous stocks by employing a classification scheme similar to that of Nehlsen et al. (1991). Assessments were possible for 5,487 (57%) of all stocks and included all large, commercially important stocks. The assessments found 624 stocks were at high risk, 78 were at moderate risk, 230 were of special concern, and 142 were extirpated in this century. We were unable to classify 4,172 (43%) of the stocks because of an absence of reliable data. Due to their small size, these stocks are not of great commercial importance, although they are important to the maintenance of salmonid diversity. We also identified many potential threats to anadromous salmon stocks. The absence of systematic, high-quality assessments at the biological stock level precluded reliable assignment of the specific causes for many of the stocks apparently at risk. Nevertheless, habitat degradation associated with logging, urbanization, and hydropower development contributed to most of the 142 documented stock extinctions. Furthermore, there is little doubt that overutilization by commercial and recreational fisheries has in many cases resulted in severe stock depressions that, when added to other factors, has put many stocks at risk.

Codes: review basin lulc ripar hydro warning

Smith, H. A., S. P. Blachut, and B. Bengeyfield. 1987. Study Design for Fisheries and Hydrology Assessment in a Glacial Watershed in British Columbia. In Regulated Streams: Advances in Ecology. Plenum Press, New York.

In Canada those rivers with glaciated catchments and salmonids primarily include major rivers which transect the Coast Mountains, of which the Homathko River is an example. These river basins are characterized by very rugged topography, steep gradients, high precipitation and heavy glaciation. The rivers are utilized by significant runs of wild stocks of anadromous and resident salmonids. This combination of important fisheries stocks utilizing complex mountainous glacial rivers in remote locations presents numerous problems beyond a typical instream flow assessment, including a study design, logistics and lack of historical data. These glacial river systems present a very dynamic physical environment. As a result, the fish populations are adapted to such variability. Study methodologies require considerable assessment and modification to the specific river under investigation. ' Off-the-shelf ' models will not necessarily address all the significant parameters identified by hydrology-fisheries linkage studies. The importance of understanding the habitat-population linkages must not be underestimated, as the ultimate result of an impact assessment should be in terms of number of fish, area of habitat. (See also W89-01736) (Lantz-PTT).

Codes: multi design hydro warning

Solazzi, M. F., T. E. Nickelson, S. L. Johnson, and J. D. Rodgers. 2000. Effects of increasing winter rearing habitat on abundance of salmonids in two coastal Oregon streams. CJFAS 57: 906-914.

A BACI (before-after-control-impact) experimental design was used to examine the effects of increasing winter habitat on the abundance of downstream migrant salmonids. Two reference streams and two treatment streams were selected in the Alsea and Nestucca basins of Oregon. Population parameters for juvenile coho salmon (Oncorhynchus kisutch), age-0 trout (Oncorhynchus spp.), steelhead (Oncorhynchus mykiss), and coastal cutthroat trout (Oncorhynchus clarki) were estimated each year for 8 years in each stream. Stream habitat was modified to increase the quality and quantity of winter habitat during the summers of 1990 (Nestucca Basin) and 1991 (Alsea Basin). Complex habitat was constructed by adding large woody debris to newly created alcoves and dammed pools. Numbers of coho salmon summer juveniles and smolts increased in the treatment streams relative to the control streams during the posttreatment period. Overwinter survival of juvenile coho salmon also increased significantly in both treatment streams posttreatment. Summer trout populations in the treatment streams did not change, but downstream migrant numbers the following spring did increase. These increases suggest that winter habitat was limiting abundance of all three species.

Codes: experi multi reach quant lwd offchann

Solazzi, M. F., T. E. Nickelson, S. L. Johnson, and S. Van de Wetering. 1997. Juvenile sea-run cutthroat trout: Habitat utilization, smolt production, and response to habitat modification. Edited by J. D. Hall, P. A. Bisson and R. E. Gresswell. American Fisheries Society, Oregon Chapter, Corvallis, Oregon (USA)

Increased focus on the status of anadromous salmonid populations and habitat in the Pacific Northwest has led to the idea that instream habitat modification projects may be a useful tool to help aid in the recovery of declining populations. To evaluate how effective these projects are at increasing salmonid populations, we need to have a general understanding of the specific habitats used by these fish during each season. With this information we can better determine the type and amount of habitat that is in shortest supply to the fish. Once these have been identified, the habitat modification project can be designed to help fill the need for a specific type of habitat. The purpose of this paper is to briefly describe the habitat-specific population data on juvenile cutthroat trout that we have collected from Oregon coastal streams and to describe the results from two habitat modification projects undertaken by the Bureau of Land Management in an effort to increase anadromous salmonid smolt production. This information should be helpful in designing more effective habitat modification projects. This paper presents only the cutthroat trout portion of our results. We have collected similar information on coho salmon and steelhead.

Codes: design instream experi

Spalding, S., N. P. Peterson, and T. P. Quinn. 1995. Summer distribution, survival, and growth of juvenile coho salmon under varying experimental conditions of brushy instream cover. Transactions of the American Fisheries Society 124: 124-130.

Woody debris is an important feature of streams, and its presence and abundance have been correlated with the abundance, growth, and survival of juvenile salmonids. To investigate the proximatemechanisms linking brushy woody debris to salmonid fishes, we determined, over a 1-month period in summer, the spatial distribution of juvenile coho salmon Oncorhynchus kisutch introduced into an outdoor experimental stream containing riffle-pool units that had one of four different levels of instream brushy-debris complexity. We then equalized the fish density in each unit and monitored fish growth and survival over a 15-week period. Coho salmon distribution, growth, and survival varied greatly but were not consistently related to the complexity of brushy debris.

Codes: experi quant habitat lwd

Stalnaker, C. B., K. D. Bovee, and T. J. Waddle. 1996. Importance of the temporal aspects of habitat hydraulics to fish population studies. Regulated Rivers Research & Management 12: 145-153.

The direct and indirect influences of hydrology and hydraulics on the usability of stream habitats by stream fish are discussed. Most habitat-hydraulic models in use today emphasize the spatial aspects of habitat quality and quantity. It is our contention that the temporal dynamics of habitat quantity are a major influence, determining fish population responses in riverine environments. This may manifest through dramatic shifts in the velocity and temperature distributions over seasons and years as influenced by climatic conditions as well as reservoir operations. Time series simulations of usable habitat available to various life stages of brown and rainbow trout and smallmouth bass populations demonstrate that the usable space and its stability during the early life history is directly translated into year-class-strength for these fish populations. Riverine ecosystems are temporally dynamic due to the stochastic nature of precipitation events. Therefore an understanding of the temporal aspects of streamflow and habitat is essential to designing water management schemes intended to protect, enhance or restore riverine fish populations.

Codes: ifim hydro temporal hem

Steingrimsson, S. O., and J. W. A. Grant. 1999. Allometry of territory size and metabolic rate as predictors of self-thinning in young-of-the-year Atlantic salmon. Journal of Animal Ecology 68: 17-26.

Self-thinning is a progressive decline in population density caused by competitively induced losses in a cohort of growing individuals and can be depicted as: log sub(10) (density) = c - beta log sub(10) (body mass). 2. In mobile animals, two mechanisms for self-thinning have been proposed: (i) the space hypothesis predicts that maximum population density for a given body size is the inverse of territory size, and hence, the self-thinning slope is the negative of the slope of the allometric territory-size relationship; (ii) the energetic equivalence hypothesis predicts that the self-thinning slope is the negative of the slope of the allometric metabolic rate relationship, assuming a constant supply of energy for the cohort. 3. Both hypotheses were tested by monitoring body size, population density, food availability and habitat for young-of-the-year Atlantic salmon (Salmo salar) in Catamaran Brook, New Brunswick. The results were consistent with the predictions of the space hypothesis. Observed densities did not exceed the maximum densities predicted and the observed self-thinning slope of -1 times 16 was not significantly different from the slope of -1 times 12, predicted by the allometry of territory size for the population under study. 4. The observed self-thinning slope was significantly steeper than -0 times 87, predicted by the allometry of metabolic rate, perhaps because of a gradual decline in food abundance over the study period. The decline in density was more rapid in very shallow sites and may have been partly caused by a seasonal change in water depth and an ontogenetic habitat shift rather than solely by competition for food or space. 5. The allometry of territory size may be a useful predictor of self-thinning in populations of mobile animals competing for food and space.

Codes: reach quant popdyn instream trophic

Steward, C., and T. C. Bjornn. 1990. Fill'er up: Stream carrying capacity. Focus Renewable Resour. 15: 16-17.

How many fish can a stream support? What factors are responsible for variations in fish abundance? To answer these questions, three years of study on the distribution, abundance, and behavior of juvenile steelhead trout (Oncorhynchus mykiss) and chinook salmon (O. tshawytscha) in relation to several key habitat features were completed: streamflow, pool morphology, cover, and water temperature. Habitat quality and quantity, along with food availability, are important factors governing in the production of seaward migrating juvenile salmon and trout in Idaho's streams. The general hypothesis was that because these juvenile fish are habitat specialists and thus sensitive to their surroundings, the physical characteristics of a stream should dictate its "carrying capacity", that is, the upper limit on the number of fish it can support.

Codes: quant instream trophic

Stoneman, C. L., and M. L. Jones. 2000. The influence of habitat features on the biomass and distribution of three species of southern Ontario stream salmonines. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 129: 639-657.

We developed models to predict habitat use and productive capacity of brook trout Salvelinus fontinalis, brown trout Salmo trutta, and rainbow trout Oncorhynchus mykiss in southern Ontario streams using readily measured habitat variables. We collected habitat and fish biomass data from 118 streams distributed throughout southern Ontario. Our habitat variables included those for morphology and substrate, water quality, instream physical habitat types, and bank vegetation. We used trout biomass, estimated from a single-pass electrofishing technique, as our indicator of site productive capacity. A discriminant function model showed modest separation among sites with low, moderate, high, and very high total trout biomass, based on differences in water temperature, percent pools, substrate, and cover. The discriminant function correctly classified sites in 80 of 118 cases. A regression tree model indicated that water temperature was by far the most important habitat variable at distinguishing sites with differing total trout biomass. A second, species-level discriminant analysis showed better separation among sites (65 of 82 cases correctly classified) where trout biomass was dominated by rainbow, brook, or brown trout; this was based on differences in water temperatures, percent pools, substrate size, average competitor biomass, and cover. A classification tree model yielded similar results. Our results are consistent with an earlier modeling effort to predict trout biomass from habitat in southern Ontario streams. Our findings add to those by (1) increasing the geographic breadth of the data used to fit the models, (2) providing a model for which all the requisite data for a site can be collected in a single day, and (3) showing that species-level models are better at linking habitat to fish biomass than are total trout biomass models.

Codes: multi reach quant instream wtemp substrate wtaqual modeling

Stoneman, C. L., M. L. Jones, and L. Stanfield. 1996. Habitat suitability assessment models for southern Ontario trout streams. Model development and evaluation. Report multi reach quant instream wtemp substrate wtaqual ifim warning hem.

The Canadian government's 1986 Policy for the Management of Fish Habitat, and in particular its "No Net Loss" guiding principle, has heightened our awareness of the need for better tools to evaluate the impacts of human activity on the productive capacity of fish habitat. Using trout biomass as a measure of productive capacity, we collected biomass and habitat data from 118 sites across southern Ontario to test the models. Data collected in 1992 showed that the existing rainbow Oncorhynchus mykiss, brown Salmo trutta and brook Salvelinus fontinalis trout HSI models are poor predictors of biomass. We developed new, modified, HSI-type models, and these provide substantially better predictions than the original models. When we tested the new models using data collected in 1993, they performed equally well. Deviations from the expected biomass at individual sites were frequently attributable to probable biotic interactions with other salmonid species.

Codes: multi reach quant instream wtemp substrate wtaqual ifim warning hem

Strange, R. J., and J. W. Habera. 1998. No net loss of brook trout distribution in areas of sympatry with rainbow trout in Tennessee streams. Transactions of the American Fisheries Society 127: 434-440.

Lowest distributional elevations for brook trout Salvelinus fontinalis in 25 streams in east Tennessee were determined during 1991-1995 to evaluate changes related to encroachment and possible replacement by rainbow trout Oncorhynchus mykiss since surveys conducted during 1978-1984. No efforts to remove rainbow trout or enhance brook trout populations were made in these streams during the 7-16-year intervals between surveys. Compared with the earlier surveys, brook trout distributions receded (lower elevation increased) in nine streams (36%), advanced (lower elevation decreased) in eight streams (32%), and did not change in eight streams (32%). The average total change in stream length occupied by brook trout was a 109-m downstream increase (SE = 82) with a mean annual increase of 8 m (SE = 6). Neither average total change nor annual change was significant ($P > 0.19$). Additionally, the highest elevations at which rainbow trout were present (determined in 10 streams) increased in four streams but decreased in six. The average total change in stream length occupied by rainbow trout was a

158-m decrease in elevation (SE = 151) with a mean annual change of -14 m (SE = 13). Neither average total change nor mean annual change was significant (P > 0.30). We concluded that rainbow trout were not affecting the downstream limit of most brook trout populations where the two species occurred sympatrically in Tennessee. Further, after examining published data from Great Smoky Mountains National Park, we found no evidence that the downstream limits of brook trout distribution in most streams were affected by the presence of rainbow trout between the 1950s and 1970s. These data support an emerging theory that the distributional limits of brook trout and rainbow trout in sympatry in the southern Appalachian Mountains will ebb and flow upstream and downstream over time.

Codes: multi reach quant sppinter temporal noenv

Stuber, R. J., R. R. Johnson, C. D. Ziebell, D. R. Paton, P. F. Ffolliott, and R. H. Hamre. 1985. Trout habitat, abundance, and fishing opportunities in fenced vs unfenced riparian habitat along Sheep Creek, Colorado. Report; Conference RM-120.

Fencing was used to protect 40 hectares of riparian stream habitat along 2.5 km of Sheep Creek, Colorado, from adverse impacts due to heavy streamside recreation use and cattle grazing. Fish habitat within the fenced area was narrower, deeper, had less streambank alteration, and better streamside vegetation than comparable unfenced sections. Estimated trout standing crop was twice as great, and proportional stock density (PSD) was higher than in unfenced sections. There was a higher proportion of nongame fish present in unfenced sections. Projected fishing opportunities within the fenced sections were double those estimated for a comparable length of unfenced habitat along the same stream.

Codes: reach experi graz ripar instream quant

Swales, S. 1982. A ' Before and After ' Study of the Effects of Land Drainage Works on Fish Stocks in the Upper Reaches of a Lowland River. Fisheries Management 13: 105-114.

Fish populations were markedly changed in the upstream reaches of the River Soar, Leicestershire, after river channel works improved land drainage. The study site was a 100 m slow-flowing reach 1 m deep, with shallow riffles at its upstream and downstream limits and abundant bankside trees and vegetation. The drainage scheme consisted of river dredging and widening and vegetation clearance, designed to reduce floodingon 360 ha of agricultural land. Although water quality parameters, flow conditions, add bottom substrate before (5/5/77) and after (3/15/79) channel works were not different, there was a marked decrease in instream cover. Mean densities of fish > 10 cm long were 0.160 per sq m before and 0.048 per sq m after the project. The mean standing crop of fish was 39.0 g per sq m before and 9.6 g per sq m after the project. Reductions in standing crop were: brown trout, 100%; chub, 81%; dace, 72%; and roach, 15%. (Cassar-FRC).

Codes: experi quant instream ripar

Swales, S. 1988. Utilization of off-channel habitats by juvenile coho salmon (Oncorhynchus kisutch) in interior and coastal streams in British Columbia. Edited by V. Sladecek. VERH. INT. VER. THEOR. ANGEW. LIMNOL./PROC. INT. ASSOC. THEOR. APPL. LIMNOL./TRAV. ASSOC. INT. LIMNOL. THEOR. APPL. vol. 23, no. 3

In streams and rivers throughout British Columbia, Canada, juvenile coho salmon (Oncorhynchus kisutch) show a strong preference for still or slow-flowing habitats with abundant cover. During the summer rearing period, juvenile coho are generally most abundant in main channel pools, they find cover among submerged root wads, logs, branches and other organic debris common in streams in the Pacific Northwest. As water temperatures decrease during autumn and early winter, coho show large-scale migrations away from summer rearing areas to tributaries, back-channels, sloughs, ponds and lakes in which they overwinter. Studies were carried out to evaluate the use of small ponds, lakes and other off-channel habitats as overwintering and rearing areas for juvenile coho in the

Coldwater R., a second-order tributary of the Fraser R. in interior B.C., and the Keogh R., a small coastal river in north-eastern Vancouver Island. Small ponds and side-channels were the preferred overwintering areas for juvenile coho in the Coldwater R., with densities of up to 4,000 coho overwintering in a small (1 ha) pond in the upper reaches of the river.

Codes: quant? habitat offchann

Swales, S., R. B. Lauzier, and C. D. Levings. 1986. Winter habitat preferences of juvenile salmonids in two interior rivers in British Columbia. CJZ 64: 1506-1514.

The winter distribution and abundance of juvenile salmonids was investigated in various main channel and off-channel habitats in the Coldwater and Nicola rivers in the southern interior of British Columbia. Catches were generally low in all main channel habitats, with coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri) being most abundant and chinook salmon and Dolly Varden char being present in smaller numbers. Coho salmon and steelhead trout catches were generally highest in pools with abundant instream and riparian cover. Steelhead trout was the main species in riprap bank protected areas, although catches were generally low. Highest overall catches were recorded in side channels and off-channel ponds, where water temperatures were usually several degrees higher than in the main river. The authors conclude that juvenile salmonids in the rivers investigated showed considerable habitat segregation during the winter. As in coastal rivers, juvenile coho salmon made extensive use of off-channel ponds, while rainbow trout and chinook salmon were generally most abundant in riprap and deep pools containing log debris, respectively.

Codes: multi habitat quant ripar offchann wtemp instream lwd

Swales, S., and C. D. Levings. 1989. Role of off-channel ponds in the life cycle of coho salmon (Oncorhynchus kisutch) and other juvenile salmonids in the Coldwater River, British Columbia. CJFAS 46: 232-242.

Off-channel ponds in the upper reaches of the Coldwater River, British Columbia, were major rearing areas for juvenile coho salmon (Oncorhynchus kisutch). Chinook salmon (Oncorhynchus tshawytscha), steelhead trout (Salmo gairdneri), and Dolly Varden char (Salvelinus malma) were generally scarce in the ponds, although they were numerous in the main river. Coho salmon were predominant at "natural" river sites while steelhead trout was the main species at sites with "rip-rap" bank stabilization. Catches of juvenile coho were much lower in the main river than in the ponds where they were the main species, and were more variable in the river.

Codes: quant reach offchann instream

Symons, P. E. K., and M. Heland. 1978. Stream habitats and behavioral interactions of underyearling and yearling Atlantic salmon (Salmo salar). J. Fish. Res. Board Can. 35: 175-183.

From an examination of over 20 yr of data from the Northwest Miramichi River and some additional data from small tributaries to the Nashwaak River, highest densities of 100 underyearling and 80 yearling or older Atlantic salmon (Salmo salar) per 100 m SUP-2 were found at sites where water velocities averaged 50-65 cm/s. At sites with lower or higher water velocities maximum observed densities decreased. Experiments in laboratory streams demonstrated that underyearling Atlantic salmon <7 cm (total length) occurred in shallow (10-15 cm) pebbly (1 . 6-6 . 4 cm diam) riffles of natural streams by choice. As they grew they began to prefer deeper (>30 cm) riffles with boulders (>25.6 cm diam). Yearlings >10 cm reduced the numbers of underyearlings <6 cm in these deeper habitats by chasing them, and occasionally by catching and eating them. Social interactions, such as displays used in territorial defence, did not occur between yearlings and underyearlings until the latter exceeded 6.5 cm, the size at which they began to move to deeper riffles. Planting densities for hatchery-reared salmon recommended in the literature were refined, taking the space and habitat requirements of different-sized juvenile salmon into account.

Codes: microhab lab quant instream

Tait, C. K., J. L. Li, G. A. Lamberti, T. N. Pearsons, and H. W. Li. 1994. Relationships between riparian cover and the community structure of high desert streams. Journal of the North American Benthological Society 13: 45-56.

The authors study reaches on 3rd-order tributaries of the John Day River in eastern Oregon included riparian areas ranging from denuded, heavily grazed streambanks to intact forest. Average summer solar inputs to these sites varied from 165 to 2230 megajoules/m super(e), and stream temperatures were influenced by the density and extent of canopy. Densities of steelhead trout (Oncorhynchus mykiss) and sculpin (Cottus spp.) decreased significantly with greater incident radiation and higher stream temperatures. Periphyton standing crops closely tracked solar inputs and was, in turn, strongly positively correlated with biomasses of total invertebrates and of grazers. The large-bodied caddisfly Dicosmoecus accounted for the higher total invertebrate biomass observed in exposed sites. These insects composed 55-96% of the total biomass in open reaches.

Codes: reach multi graz ripar wtemp trophic quant

Taugboel, T., and R. Andersen. 1986. Effect of habitat change on the density of brown trout Salmo trutta in a small stream. Fauna (Blindern) 39: 98-102.

The authors estimated number and density of parr (> 0 +) and resident trout, Salmo trutta, in the small stream, Austadbekken, in 1982, 1983 and 1985. In 1984 the lower part of the stream was canalised, reducing the habitat heterogeneity drastically. In 1982/83 the habitat was heterogeneous with numerous hiding places, whereas the habitat was more homogenous after the canalisation. In the upper part of the stream there were no significant difference in fish density between the three years. In the lower part there were no significant difference in density between 1982 and 1983. In 1985, however, the density was reduced by 90% compared to 1982 and 1983. The reduced density in the lower part in 1985 was probably due to the dramatic habitat change. Trout individuals are territorial, and homogeneous habitats with few hiding places therefore support less fish compared to more heterogeneous habitats.

Codes: experi quant instream

Taylor, E. B. 1991. Behavioural interaction and habitat use in juvenile chinook, Oncorhynchus tshawytscha, and coho, O. kisutch, salmon. Animal Behaviour 42: 729-744.

Young anadromous chinook salmon and coho salmon reside sympatrically in many streams and rivers tributary to the North Pacific Ocean. This study tested the hypothesis that behavioural domination by coho salmon, which reside in freshwater for at least 1 year before seaward migration, promotes variability in habitat use and in the duration of freshwater residence by chinook salmon, which migrate seaward in their first year of life ("ocean-type") or after a year or more in freshwater ("stream-type" chinook). In laboratory stream channels coho behaviourally dominated chinook; they spent more time attacking chinook than vice versa and numerically dominated upstream sections of the channels where food was introduced. Principal components analysis was used to study habitat used by coho and chinook in four natural streams. In two streams where they were sympatric, coho and chinook used different habitats: coho used slow water, deep "pool" areas while chinook used faster water, shallow "riffle" areas. In two streams where chinook were allopatric, however, they made greater used of pool habitats than when in sympatry.

Codes: experi enclos qual microhab sppinter

Theurer, F. D., I. Lines, and T. Nelson. 1985. Interaction Between Riparian Vegetation, Water Temperature, and Salmonid Habitat in the Tucannon River. Water Resources Bulletin 21: 53-64.

The Tucannon River watershed is located in southeastern Washington. The upper third of the watershed is on public land and has enough riparian vegetation and clean substrate to serve as satisfactory salmonid spawning and rearing habitat. The lower two-thirds is on privately owned land; here the river has lost most of its vegetation and is not satisfactory for either rearing or spawning habitat. Physical-process, ecological, and economic models are used to: analyze the instream water temperatures with respect to existing and proposed riparian vegetation under natural conditions; use these water temperatures to determine salmon and steelhead fish populations that were based upon actual field count and known temperature preference data; and determine the economic worth based upon the estimated carrying capacity of the river, the estimated number of return spawners, and the economic value of commercially caught and sport-caught salmon and steelhead. The analysis demonstrates the efficacy of multidisciplinary modeling efforts to relate riparian vegetation, water temperature, and salmonid habitat. The economic results clearly indicate the value and feasibility of restoring riparian vegetation on the Tucannon River. The total cost for restoring the entire thermal regime would be less than 1.5 million dollars, as contrasted to the present worth of 6.9 million dollars. (Moore-IVI).

Codes: reach quant modeling wtemp ripar economic

Thompson, W. L., and D. C. Lee. 2000. Modeling relationships between landscape-level attributes and snorkel counts of chinook salmon and steelhead parr in Idaho. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 1834-1842.

Knowledge of environmental factors impacting anadromous salmonids in their freshwater habitats, particularly at large spatial scales, may be important for restoring them to previously recorded levels in the northwestern United States. Consequently, existing data sets were used and an information-theoretic approach to model landscape-level attributes and snorkel count categories of spring-summer chinook salmon (Oncorhynchus tshawytscha) and steelhead (Onorhynchus mykiss) parr within index areas in Idaho. Count categories of chinook salmon parr were negatively related to geometric mean road density and positively related to mean annual precipitation, whereas those for steelhead parr were negatively related to percent unconsolidated lithology. These models predicted that chinook salmon parr would be in low count categories within subwatersheds with >1 km times km super(-2) geometric mean road densities and (or),700 mm mean annual precipitation. Similarly, steelhead parr were predicted to be in low count categories in subwatersheds with .30% unconsolidated lithology. These results provide a starting point for fish biologists and managers attempting to map approximate status and quality of rearing habitats for chinook salmon and steelhead at large spatial scales.

Codes: multi reach basin qual lulc modeling

Thurow, R. F., D. C. Lee, and B. E. Rieman. 1997. Distribution and status of seven native salmonids in the interior Columbia River basin and portions of the Klamath River and Great basins. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 17: 1094-1110.

We summarized presence, absence, current status, and potential historical distribution of seven native salmonid taxa - bull trout Salvelinus confluentus, Yellowstone cutthroat trout Oncorhynchus clarki bouvieri, westslope cutthroat trout O. c. lewisi, redband trout and steelhead O. mykiss gairdneri, stream type (age-1 migrant) chinook salmon O. tshawytscha, and ocean type (age-0 migrant) chinook salmon - in the interior Columbia River basin and portions of the Klamath River and Great basins. Potential historical range was defined as the likely distribution in the study area prior to European settlement. Data were compiled from existing sources and surveys completed by more than 150 biologists. Within the potential range of potamodromous salmonids, status was unknown in 38-69% of the area, and the distribution of anadromous salmonids was unknown in 12-15%. We developed models to quantitatively explore relationships among fish status and distribution, the biophysical environment, and land management, and used the models to predict the presence of taxa in unsampled areas. The composition, distribution, and status of fishes within the study area is very different than it was historically. Although several of the salmonid taxa are distributed throughout most of their potential range, declines in abundance and distribution and fragmentation into smaller patches are apparent for all forms. None of the salmonid taxa have known or predicted strong populations in more than 22% of their potential ranges, with the exception of Yellowstone cutthroat trout. Both forms of chinook salmon are absent from more than 70% and steelhead from more than 50% of their potential ranges, and all are approaching extirpation in portions of their remaining ranges. If current distributions of the taxa are useful indicators, many aquatic systems are remnants of what were larger and more complex, diverse, and connected systems. Because much of the ecosystem has been altered, areas supporting strong populations or multiple species will be critical for conservation management. Moreover, restoration of a broader matrix of productive habitats also will be necessary to allow fuller expression of phenotypic and genotypic diversity in native salmonids.

Codes: multi modeling basin qual lulc

Thurow, R. F., D. C. Lee, and B. E. Rieman. 2000. Status and distribution of chinook salmon and steelhead in the interior Columbia River basin and portions of the Klamath River basin. Edited by E. E. Knudson, C. R. Steward, D. D. MacDonald, J. E. Williams and D. W. Reiser. CRC Press LLC, 2000 Corporate Blvd., NW Boca Raton FL 33431 USA

This chapter summarizes information on presence, absence, current status, and probable historical distribution of steelhead Oncorhynchus mykiss and stream-type (age-1 migrant) and ocean type (age-0 migrant) chinook salmon O. tshawytscha in the interior Columbia River basin and portions of the Klamath River basin. Data were compiled from existing sources and via surveys completed by more than 150 biologists working in the region. We developed models to quantitatively explore relationships among fish status and distribution, the biophysical environment, and land management. Biophysical setting was an important determinant of species distributions and habitat suitability. We applied model results to predict fish presence in unsampled areas and mapped expecteddistributions in more than 3,700 subwatersheds. Chinook salmon and steelhead are extirpated from more than 50% of their potential historical ranges. Most remaining populations are severely depressed; less than 2% of the watersheds in the current range were classified as supporting strong populations of steelhead or stream-type chinook salmon. Wild, indigenous fish are rare; 22% of remaining steelhead stocks and less than 17% of chinook salmon stocks were judged to be genetically unaltered by hatchery-reared fish. Much of the historical production has been eliminated. However, a core for maintaining and rebuilding functional areas remains. Protection of core areas critical to stock persistence and restoration of a broader matrix of productive habitats will be necessary for productive and sustainable fisheries. This effort will require conservation and restoration of sufficient habitats to ensure the full expression of phenotypic and genotypic diversity in chinook salmon and steelhead.

Codes: multi modeling qual basin lulc

Tripp, D. B., and V. A. Poulin. 1992. Effects of logging and mass wasting on juvenile salmonid populations in streams on the Queen Charlotte Islands. Report 0-7718-9258-6.

The effects of logging and mass wasting on juvenile coho salmon and Dolly Varden char were assessed in streams on the Queen Charlotte Islands. Fish densities and habitat characteristics of 27-33 stream reaches were measured during summer and fall. Reach samples included undisturbed, unlogged oldgrowth forest, logged streams not directly affected by recent mass wasting (logged), and logged streams directly affected by recent debris torrents and slides (mass wasted). Overwinter survivals and smolt yields in three mass wasted and three non-mass wasted streams (all logged) were also estimated in a downstream spring fish trapping program, after determining the number of fish present in each stream the previous fall.

Codes: multi reach quant popdyn ripar

Tschaplinski, P. J. 2000. The effects of forest harvesting, fishing, climate variation, and ocean conditions on salmonid populations of Carnation Creek, Vancouver Island, British Columbia. Pages 297-328. In Sustainable Fisheries Management: Pacific Salmon. E. E. Knudson, C. R. Steward, D. D. MacDonald, J. E. Williams and D. W. Reiser, editors. CRC Press LLC, 2000 Corporate Blvd., NW Boca Raton FL 33431 USA.

The Carnation Creek Fisheries-Forestry Interaction Project, initiated in 1970, is the longest, continuous study of the effects of forestry practices on biological and physical watershed processes in North America. This case study was initially designed to investigate the effects of different streamside forest-harvest treatments on stream channels, aquatic habitats, and fish. The salmonid populations of Carnation Creek have been monitored through 5 pre-logging, 6 during-logging, and 14 post-logging years as one component of this multidisciplinary study. Forest harvesting has had complex and often variable effects upon Carnation Creek fish species and life stages. Chum salmon Oncorhynchus keta have shown the sharpest decline. After logging, numbers of adults returning to the stream fell to about one third of the pre-logging average. This decline is due partly to reductions in egg-to-fry survival resulting from decreased quality of spawning and egg-incubation habitats in the lowermost stream reach. Reductions in summer rearing habitat appear to explain the roughly 50% post-logging decline in abundance of coho salmon O. kisutch fry inhabiting the stream. However, the fewer coho fry have produced >1.5-times more smolts after logging due to improved overwinter survival, which is in turn correlated with increased winter water temperatures and summer growth. Increased smolt abundance has not caused more adults to return. Coho returning to the system have declined after logging by 31%, due at least partly to both depressed marine survivals resulting from earlier timing of spring smolt migrations and ocean climate shifts. The production of salmonids from coastal streams clearly depends upon processes occurring both within watersheds and the marine environment. We cannot control natural shifts in marine ecosystems and climate. Therefore, to sustain our salmonid resources, we must always apply our best forest-harvest practices to ensure that adverse effects of natural variations are not compounded with those of inappropriate land use.

Codes: experi reach basin quant ripar lulc temporal

Tschaplinski, P. J., and G. F. Hartman. 1983. Winter distribution of juvenile coho salmon (Oncorhynchus kisutch) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. Canadian Journal of Fisheries and Aquatic Sciences 40: 452-461.

Numbers of juvenile coho salmon (O. kisutch) in streams are reduced subtantially in winter compared to those that occur in summer. Most of this reduction occurs early in autumn with the onset of the first seasonal freshets. Stream sections containing adequate winter habitat in the form of deep pools, log jams and undercut banks with tree roots and debris lost fewer fish during freshets and maintained higher numbers of coho in winter than sections without these characteristics. These features provide shelter and reduce stream velocities. Microhabitats occupied by coho juveniles in winter after logging were unchanged from those described before logging -- all microhabitats were characterized by low water velocities (less than or equal to 0.3 m/s). Up to 48% of the coho population inhabiting stream sections with adequate shelter remained there by midwinter (Jan. 3). The apparent survival rate during and after logging was 67.4%, essentially unchanged from the prelogging value. Logging has neither reduced the numbers of coho juveniles that enter such sites in autumn to overwinter, nor reduced the numbers leaving these sites to reenter Carnation Creek in spring.

Codes: experi reach quant ripar instream lwd temporal

Unwin, M. J. 1997. Survival of chinook salmon, Oncorhynchus tshawytscha, from a spawning tributary of the Rakaia River, New Zealand, in relation to spring and summer mainstem flows. Fishery Bulletin [Fish. Bull.] 95: 812-825.

To characterize the impact of spring floods on the survival of juvenile chinook salmon (O. tshawytscha) in the unstable, braided rivers on the east coast of New Zealand's South Island, I examined correlations between spring and summer flows in the mainstem of the Rakaia River and fry-to-adult survival for chinook salmon spawning in a headwater tributary. Flow parameters that were investigated included mean flow, maximum flow, and the ratio of mean to median flow (an index of flow variability), calculated during peak downriver migration of ocean-type juveniles (August to January). Survival was uncorrelated with mean or maximum flow but was positively correlated with the ratio of mean to median flow during spring (October and November). The correlation suggests that pulses of freshwater entering the ocean during floods may buffer the transition of fingerlings from fresh to saline waters and thus partly compensate for the lack of an estuary on the Rakaia River. A positive correlation between spring flow variability and the proportion of ocean-type chinook in relation to stream-type chinook is also consistent with this hypothesis. All correlations were relatively weak, reinforcing earlier results that production is primarily controlled by marine influences. These findings further demonstrate the considerable ability of chinook salmon to adapt to new habitats.

Codes: reach basin popdyn hydro noenv

Urabe, H., and S. Nakano. 1999. Linking microhabitat availability and local density of rainbow trout in low-gradient Japanese streams. Ecological Research [Ecol. Res.] 14: 341-349.

Quantification of reach-based microhabitat availability for rainbow trout (Oncorhynchus mykiss), considering their microhabitat requirements in two low-gradient streams, northern Japan, was attempted to test for habitat space limitation of local trout density. Underwater observations revealed that fish selected microhabitats of moderate current velocity, relatively greater depth and shorter distance to overhead cover in both streams, although habitat features used and available differed slightly between the streams. Habitat space for fish potentially available in the channel environment was evaluated using principal component analysis (PCA) of both available and used microhabitat. A close relationship was evident in both streams between reach-based microhabitat availability and fish density, which was assessed by a three-pass removal method. Direct estimates of fish microhabitat availability using PCA can contribute to accurate predictions of local fish density and provide insight into the mechanisms responsible for fish-habitat relationships in streams.

Codes: multi reach microhab quant instream

Usio, N., and S. Nakano. 1998. Influences of microhabitat use and foraging mode similarities on intra- and interspecific aggressive interactions in a size-structured stream fish assemblage. Ichthyological Research [Ichthyol. Res.] 45: 19-28.

Aggressive interactions, foraging behaviour and microhabitat use were observed among four sympatric stream fishes inhabiting the water column: ayu (Plecoglossus altivelis), white-spotted charr (Salvelinus leucomaenis), masu salmon (Oncorhynchus masou) and Japanese dace (Tribolodon hakonensis), each species being categorised into five body-size classes (species-size groups; SSG's). Aggressive interactions were observed between most pairs of SSG's, an almost linear dominance order being apparent throughout the three-month study period. Ayu were relatively subordinate in June, but became the second most dominant in July and the most dominant in August, as a consequence of a reversal in dominance order with salmon. In contrast, smaller-sized dace, which continually suffered from intra- and interspecific aggression, occupied the most subordinate ranks throughout the study period. Intensive aggression was observed among various SSG's, exhibiting same microhabitat propensity throughout the three months. The direction and frequency of aggressive interactions varied month by month due to a reversal in dominance order between ayu and masu salmon, and/or changes in density, body size and resource use of the component members. Opponent selectivity was higher within SSG's, where resource use was assumed to be highly overlapping, rather than among SSG's throughout the study period. Correlation analysis indicated that opponent selectivity in aggressive interactions among SSG's was positively correlated with similarity in microhabitat selectivity in June, but not in other months or with that in foraging habits, suggesting that intensive aggressive behaviour reflected overlapping habitat use among assemblage members during a certain period.

Codes: microhab sppinter qual

Usio, N., and N. Shigeru. 1998. Temporal variation in foraging group structure of a size-structured stream fish community.

Temporal variation in foraging group structure of s fish assemblage was examined in a flood-prone stream in southern Hokkaido, japan. Foraging behaviour was observed underwater for four species which inhabit the water column: ayu, Plecoglossus altivelis, white-spotted char, Salvelinus leucomaenis, masu salmon, Oncorhynchus masou, and Japanese dace, Tribolodon hakonensis, with each species being categorized into five size classes (species-size group; SSG). based on foraging behaviour, each SSG of the fish assemblage was classified into one of four foraging groups: algae grazers, drift foragers, benthos-drift foragers, and omnivores, defined as SSG exhibiting similar foraging behaviour. All size classes of ayu, and of charr and salmon were categorized as algae grazers and drift foragers, respectively, throughout the study period. In contrast, size classes of dace were categorized as drift foragers, benthos-drift foragers, or omnivores with the same size classes often assigned to different foraging groups from month to month. Digestive tract contents of the fishes in the four foraging groups reflected their observed foraging behaviour, and foraging groups were therefore regarded as representing trophic groups. Abundance and membership of each foraging group varied in accordance with changes in abundance of SSG due to their growth, immigration, emigration, and/or mortality. Moreover, due to numerical dominance within the assemblage, plasticity in foraging behaviour of small- and medium-sized dace also played a key role in determining variability in the foraging group structure. Relative frequencies of two types of foraging behaviour, algae nipping and benthos foraging, of the small-sized dace were significantly correlated with the level of each resource, whereas no significant relationship was detected between foraging frequencies of the medium-sized dace and either resource. Fluctuations in foraging group structure within this assemblage occurred through niche shifts of some component members and by changes in SSG composition.

Codes: habitat quant migrat sppinter trophic

Van Winkle, W., H. I. Jager, S. F. Railsback, B. D. Holcomb, T. K. Studley, and J. E. Baldrige. 1998. Individual-based model of sympatric populations of brown and rainbow trout for instream flow assessment: model description and calibration. Ecological Modelling [Ecol. Model.] 110: 175-207.

This paper describes an individual-based model of sympatric populations of brown (Salmo trutta) and rainbow trout (Oncorhynchus mykiss in a stream habitat. The model provides a tool for projecting flow and temperature effects on trout populations by linking the hydraulic component of the instream flow incremental methodology/physical habitat simulation system (IFIM/PHABSIM) to an individual-based population model. PHABSIM simulates the spatial distribution of depth and velocity at different flows, and indirectly, the availability of spawning habitat, cover and feeding station. The individual-based model simulates reproduction, growth and mortality of individual trout as a function of flow and temperature. Population dynamics arise from the survival and reproduction of individual trout. The spatially explicit nature of the model permits evaluation of behavioral responses used by fish to changes in physical habitat. The model has been calibrated to a stream segment in the North Fork Middle Fork Tule River, California. Selected parameters were adjusted to calibrate the model for length and abundance (including production of a new year class) at the end of 1-year simulations for each of 9 years. Predicted and observed lengths were in good agreement, although neither varied appreciably among years. Predicted and observed abundances were not in as good agreement, and differed considerably for some years. These differences reflect a combination of uncertainties in the field data and uncertainties in the model structure and parameter values. Fifty-year simulations indicated that model projections of length and abundance were stationary, although abundance values fluctuated considerably. Seven advantages for using simulation models of this type are emphasized. How to most effectively interpret results from such simulation models as part of instream flow environmental assessments remains a challenge. Variability and uncertainty in both field data and replicate model simulations are realities that have implications for scientists, resource managers. and regulators in projecting growth and abundance responses of fish populations to alternative flow or temperature regimes.

Codes: modeling habitat instream popdyn ifim warning hem

Van Zyll de Jong, M. C., I. G. Cowx, and D. A. Scruton. 1997. An evaluation of instream habitat restoration techniques on salmonid populations in a Newfoundland stream. Regulated Rivers: Research & Management [Regul. Rivers: Res. Manage.] 13: 603-614.

The effect of three types of habitat improvement structures were evaluated in Joe Farrell's Brook, a small second order salmonid stream in Newfoundland, Canada which had been adversely affected by forest harvesting activities. Fish populations and key habitat attributes were monitored prior to and, in two subsequent years after, boulder clusters, V-dams and half-log covers were placed at selected sites in channellised reaches. Boulder clusters proved to be the most effective structure, increasing densities of 0+, 1+, and 3+ juvenile Atlantic salmon (Salmo salar L.) after placement of instream devices. V-dams proved to be effective in increasing both the density of brook trout (Salvelinus fontinalis Mitchel) and Atlantic salmon through the creation of more diverse pool habitat. Half-log covers increased the number of juvenile salmon age 0+ through an increase in instream cover. These increases in salmonid abundance, however, were considered not to be solely attributed to an improvement in physical habitat. Other factors may influence or modify productivity of the stream reaches treated. For example, relative abundance, size distribution, biomass, and production are controlled by physical and chemical habitat variables and are modified through inter- and intra-specific competition. The general conclusion was that the restoration techniques increased habitat heterogeneity and the degree of habitat complexity in channellised sections; therefore, reducing competition and increasing production.

Codes: experi quant instream

Virbickas, T. 1996. Fish production in Lithuania rivers of different types. Ekologija/Ehkologiya/Ecology 4: 37-47.

Investigations of fish production in Lithuania rivers were carried out in 1993-1995. It was established that production of various fish species in Lithuanian rivers changes depending on the river type: the mean production of stenothermal rheophilic benthophagous and ichthyophagous fish species (Cottus poecilopus, Salmo trutta) is the highest in coldwater streams and coldwater middle-size rivers, that of eurithermal rheophilic benthophagous species (Alburnus alburnus, Gobio gobio) in warmwater streams, eurithermal rheophilic euriphagous species (Leuciscus cephalus) in warmwater middle-size rivers, eurithermal rheo-limnophilic euriphagous species (Rutilus rutilus) in heavily eutrophicated middle-size rivers. The mean fish community production in Lithuanian rivers of various types changes depending on the river size, thermal regime and eutrophication level. Mean fish community production is the lowest in the channelized coldwater streams (P 3.74 kg/ha/yr) and the highest in the heavily eutrophicated rivers (P 28.2 kg/ha/yr). In general, fish production in coldwater rivers (range 3.74-9.67 kg/ha/yr) is much lower than in warmwater ones (range 21.6-28.2 kg/ha/yr). When compared with rivers of other European countries, ichthyocoenosis production in Lithuanian rivers is medium or low. The P/B ratio of various fish species in rivers of different type varies greatly, the lowest P/B ratios being in hardly eutrophicated rivers. Mean fish community P/B ratio is the highest in natural coldwater streams and coldwater middle-size rivers (1.02 and 0.96 respectively) and the lowest in the channelized coldwater streams and hardly eutrophicated rivers (0.55 and 0.57, respectively). Relative production of differently feeding fish species changes together with the increase of the river size, eutrophication level and changes in the thermal regime: relative production of euriphagous and planktonphagous fish species increases (0%-86.9% and 0%-4.7%, respectively), while that of benthophagous and ichthyophagous ones decreases (58.8%-2.9% and 63.5%-2.2%, respectively).

Codes: multi quant popdyn watqual noenv

Vondracek, B., and D. R. Longanecker. 1993. Habitat selection by rainbow trout, Oncorhynchus mykiss, in a California stream: Implications for the instream flow incremental methodology. Ecology of Freshwater Fish 2: 173-186.

We quantified microhabitat selection of rainbow trout (Oncorhynchus mykiss) at 2 flows (low=1.13 m super(3)/s and high=4.95 m super(3)/s) in the Pit River, California. Flows were controlled by an upstream dam and habitat availability was similar during 4 sampling periods at low flow and 2 periods at high flow. A principal components analysis reduced 6 microhabitat variables to 3 new variables that explained 80% of the observed variance. The 3 components loaded heavily on velocity variables, depth variables and substrate. Microhabitat selection generally differed among macrohabitats (i.e., pools, runs, and riffles). Rainbow trout selected different microhabitats at high flow relative to low flow in response to the availability of deeper, faster water. At low flow, depth and velocity selection were positively correlated with seasonal temperature change for adults but not juveniles. Rainbow trout apparently sought shelter in interstitial spaces in the substrate of runs and riffles during the day in early winter. Generally, large rainbow trout were observed in pools, intermediate-sized fish in runs, and small trout in riffles. The largest fish occurred in slow, deep areas of pools, where they moved slowly without orientation to flow and were not observed feeding, whereas small fish generally faced upstream and fed in all habitat types. Foraging forays were directed up in the water column at velocities similar to the mean water column velocities at holding positions. Rainbow trout were the most abundant species in 76% of the population survey stations. Other species that might have influenced microhabitat selection by rainbow trout were uncommon.

Codes: microhab qual hydro instream wtemp

Walters, C. J., J. S. Collie, and T. Webb. 1989. Experimental designs for estimating transient responses to habitat alteration: Is it practical to control for environmental interactions? Edited by C. D. Levings, L. B. Holtby and M. A. Henderson. 13-20 p.

Survival trends for hatchery salmon stocks cannot be simply compared to survival trends in wild stocks, since the hatchery stocks may be more susceptible to changes in environmental factors such as ocean temperature. To control for such time-treatment interactions, the authors suggest a "staircase" experimental design in which treatment is initiated at different times on the treated units. The transient response and interaction parameters can be computed using general linear models, while correcting for temporal trends and inherent differences among units. The performance of such a staircase design is illustrated with data on the abundance of spring chinook salmon (Oncorhynchus tshawytscha) in the Salmon River basin.

Codes: design quant

Wankowski, J. W. J., and J. E. Thorpe. 1979. Spatial distribution and feeding in Atlantic salmon, Salmo salar L. juveniles. J. Fish Biol 14: 239-247.

The distribution, social behaviour, and feeding behaviour of juvenile Atlantic salmon were studied in a selection of stream and river habitats in northern Scotland using Scuba diving techniques. the results are discussed with respect to food acquisition and choice of feeding site. It is concluded that juvenile salmon feed predominantly on drifting material and that their daytime distribution reflects the current velocity related abundance of drift.

Codes: multi microhab qual trophic instream

Wasson, J. G., R. Bonnard, and L. Maridet. 1995. Global influence of physical habitat parameters on benthic invertebrates in trout streams: towards an integration in fish-habitat models. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 291-299 p.

The influence of physical habitat parameters on macroinvertebrate densities and biomass was tested to further develop global suitability curves, in order to integrate food-producing zones in fish/habitat models. The database contains 371 samples taken from 28 trout stream reference sites in France. Substrate diameter and structure significantly influenced densities and biomass. Values were lower on cobbles than on boulders, but sandy substrates did not differ from both. Velocity and depth significantly influenced density. Densities increased with velocity, but a minimum value occurred at 60-70 cm/s. Densities decreased with depth. Differences between observed patterns and existing curves are discussed.

Codes: multi habitat nofish substrate trophic foreign

Waters, T. F. 1983. Replacement of brook trout by brown trout over 15 years in a Minnesota stream: production and abundance. Transactions of the American Fisheries Society 112: 137-146.

The trout population in Valley Creek, Minnesota, changed over 15 years from virtually 100% brook trout Salvelinus fontinalis in 1965 to predominantly brown trout Salmo trutta, with some brook trout and rainbow trout Salmo gairdneri remaining. Trout densities were 6,618*hectare^-1 in spring 1965 (all brook trout), and 3,430*hectare^-1 in spring 1980 (70% brown, 15% brook, and 15% rainbow trout). Initial standing stock in spring 1965 was 184 kg*hectare^-1 (wet weight) of brook trout; in spring 1980, brown trout standing stock was 123 kg*hectare^-1 (75%), brook trout 22 kg*hectare^-1 (13%), and rainbow 19 kg*hectare^-1 (12%), for a total of 164 kg*hectare^-1. Annual production in 1965 was 61 kg*hectare^-1 by brook trout (low owing to floods in 1965); annual production in 1979 (spring 1979 to spring 1980) was 132 kg*hectare^-1 (70%) by brown, 25 kg*hectare^-1 (13%) by brook, and 33 kg*hectare^-1 (17%) by rainbow trout, for a total of 190 kg*hectare^-1. Mean annual precipitation, greater fluctuation in annual precipitation, notable single-day rainfall events, and occurrences of floods, erosion, and siltation all increased in 1965-1979 relative to the previous 10 years. These changes apparently were the cause of observed weak year classes of trout, decreases in invertebrate food production, and loss of cover for small trout. It is postulated that innate factors in the behavior of brook and brown trout, in interaction with the habitat perturbations, may have resulted in the replacement of brook by brown trout.

Codes: reach quant popdyn sppinter substrate hydro temporal

Watson, G., and T. W. Hillman. 1997. Factors affecting the distribution and abundance of bull trout: an investigation at hierarchical scales. North American Journal of Fisheries Management 17: 237-252.

The reported declines of many stocks of bull trout Salvelinus confluentus in the Pacific Northwest has generated much interest in developing conservation and management plans to protect and rebuild populations. These plans require knowledge of the specific requirements of bull trout throughout their range. We describe the relationships between distribution and abundance of bull trout and physical and biotic factors across a large portion of their historical range. We surveyed 1,057 randomly selected sites from 93 streams within 18 major drainages throughout Washington, Idaho, and Montana for the presence of bull trout. We used logistic regression to assess the relationship between the occurrence of bull trout and several physical and biotic factors at site and habitat scales of analysis. Robust regression assessed relationships between densities of bull trout and physical parameters at site, stream, and basin scales of analysis. Bull trout occurred significantly more often in sites within alluviated lowlands and valleys and in sites with undercut banks, large substrates, pools, and where trees and shrubs were the dominant riparian vegetation. Bull trout occurrence at the site scale was inversely related to the percentage of canopy cover and vegetation overhang and the presence of brook trout S. fontinalis and rainbow trout Oncorhynchus mykiss. At the habitat scale, bull trout most often used large, deep pools that lacked extensive canopy cover. They rarely used fast-water habitats with fine sediments, extensive canopy cover, and brook trout. Bull trout densities correlated positively with pool depth, undercut banks, and diverse gradients, and indirectly with fine sediments at both the stream and site scales of analysis. In addition, high densities of bull trout with less vegetation overhang and greater, but variable, percentages of wood and boulder cover at the site scale. The combinations of variables that correlated significantly with bull trout densities varied considerably among different basins. Additionally, the amount of variation in bull trout densities explained by significant variables decreased at finer scales of analysis. These results indicate a hierarchical relationship between the distribution and density of bull trout and physical variables. Thus, land management for bull trout enhancement or protection should be site-specific and tailored within a similar hierarchical framework.

Codes: multi habitat reach segment quant ripar instream substrate

Weiss, S., and S. Schmutz. 1999. Performance of hatchery-reared brown trout and their effects on wild fish in two small Austrian streams. Transactions of the American Fisheries Society 128: 302-316.

Two small streams of contrasting physicochemical character, one crystalline and one limestone, were experimentally stocked with brown trout Salmo trutta. The study design involved doubling (three sites) or tripling (three sites) the number of large-sized resident fish (>179 or >199 mm total length, dependant on the stream) with an equal mixture of two hatchery strains; three additional sites were left unstocked as controls. In the limestone stream, short-term survival (3 months) of hatchery fish (both strains) was 80%, compared with 90% for wild fish. In the crystalline stream, survival of hatchery fish was 48% and 62% (dependant on strain), compared with 49% for wild fish. After 12 months, the survival of hatchery strains declined precipitously (range: 1-19%), compared with wild fish (range: 13-52%), dependant on stream and strain. After 3 months, about half of the recaptured hatchery fish were caught outside the 200-m-long sites in which they were stocked. Percent movement of wild fish was affected by stocking density in the limestone stream (control, 5%; doubled treatment, 14%; tripled treatment, 20%) but was unrelated to stocking density in the crystalline stream (control 32%; doubled, 20%; tripled, 28%). Stocked strains, on average, lost weight (7-11%) over the first 3 months in the limestone stream but gained weight (5-25%) over the same period in the crystalline stream. Growth of wild brown trout was negatively affected by stocking in the crystalline stream but was unaffected in the limestone stream. Despite the recorded movements, there was no significant change in the population size or biomass of wild brown trout populations due to stocking in either stream.

Codes: multi quant migrat lulc

Wesche, T. A., C. M. Goertler, and C. B. Frye. 1987. Contribution of riparian vegetation to trout cover in small streams. North American Journal of Fisheries Management 7: 151-153.

Cover is an important trout habitat component resulting from the geomorphologic characteristics of a stream channel, the stream-bank interface with the riparian community, and the stream flow. By means of regression analysis, this study quantitatively describes the relative importance of three cover parameters (overhead bank cover, rubble-boulder-aquatic vegetation areas, and deepwater areas) and two cover models as indicators of trout standing stock (Salmo trutta, S. gairdneri, Salvelinus fontinalis) in eight small streams in southeast Wyoming. Results indicated that overhead bank cover, provided primarily by riparian vegetation, is the cover parameter that explains the greatest amount of variation in trout population size.

Codes: multi reach quant ripar instream

Wesche, T. A., C. M. Goertler, C. B. Frye, R. R. Johnson, C. D. Ziebell, D. R. Paton, P. F. Ffolliott, and R. H. Hamre. 1985. Importance and evaluation of instream and riparian cover in smaller trout streams. Report; Conference RM-120.

Cover is an important trout habitat component resulting from the geomorphological characteristics of a stream channel, the streambank interface with the riparian community, and the streamflow. This paper quantitatively describes the significance of the riparian contribution to overall stream cover as related to brown trout (Salmo trutta) population size.

Codes: multi reach quant ripar instream

Wesche, T. A., C. M. Goertler, and W. A. Hubert. 1987. Modified habitat suitability index model for brown trout in southeastern Wyoming. North American Journal of Fisheries Management 7: 232-237.

The habitat suitability index (HSI) model for brown trout Salmo trutta in stream systems, developed by the U.S. Fish and Wildlife Service, was tested with data from 30 reaches on nine streams in southeastern Wyoming. The HSI was not significantly correlated ($P > 0.05$) with brown trout standing stock.

Codes: multi reach quant ifim warning hem

Whalen, K. G. 1998. Smolt Production and Overwinter Mortality of Atlantic Salmon (Salmo salar) Stocked As Fry. Dissertation.

Research was completed to determine factors affecting smolt production and overwinter mortality of Atlantic salmon (Salmo salar) stocked as fry in Vermont tributaries of the Connecticut River. Specific focuses included: (1) timing of smolt migration relative to environmental and physiological factors; (2) effect of ice formation on habitats selected and winter distribution of parr; (3) effect of maturation on parr growth and smolt recruitment; and (4) smolt production dynamics and recruitment modeling. Smolt migration timing and recruitment was determined using net weirs and counting fences and mark-recapture and winter habitat studies were completed by night snorkeling. Tributaries differed in the timing of smolt migration with the tributary warming earliest in the spring generally experiencing earlier smolt migration. Initiation and cessation of smolt migratory activity appeared to be linked to smolt physiological development. Peaks in river discharge increased smolt migratory activity after water temperature thresholds were surpassed, yet only while smolts maintained elevated gill Na +, K +-ATPase activity. Ice formation caused significant changes in the physical stream environment, including a reduction in the abundance of habitats often selected by parr. Changes in the distribution of parr over the winter generally corresponded to changes in the distribution of high velocity habitats they rarely selected and low velocity habitats they often selected. Mature parr were abundant across and within tributaries. Percent mature in October/November was positively correlated with mean size the preceding June. Studies on individually marked parr showed that mature parr exhibited poorer June to October growth than immature parr resulting in large differences in fall size. Mature parr were recruited to smolt at a reduced frequency relative to immature parr and modeling analysis indicated that this difference resulted primarily from a one-third probability of smolting for mature parr rather than differences in fall to spring survival. Simulation modeling revealed that losses in potential smolt production attributable to parr maturation may be as high as 35% when maturation percentages reach the maximum of 45% observed in this study. It is concluded that smolt physiology, winter habitat, and parr maturation are primary factors affecting smolt production and overwinter mortality of Atlantic salmon stocked as fry.

Codes: multi quant popdyn migrat hydro wtemp

Whalen, K. G., D. L. Parrish, and M. E. Mather. 1999. Effect of ice formation on selection of habitats and winter distribution of post-young-of-the-year Atlantic salmon parr. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 56: 87-96.

How ice effects determine selection of habitats and distribution of post-young-of-the-year Atlantic salmon (Salmo salar) parr during the winter, was examined. Night snorkeling surveys were completed between November and April to evaluate parr habitat use and movements. Systematic measurements of water depth and velocity were recorded during ice-free and less than or equal to 55% iced conditions to quantify habitat availability. Ice formation altered the distribution and reduced the abundance of habitats commonly used by parr; differences between parr habitat use and habitat availability were greatest when ice was present. Edge ice formation resulted in the concentration of flows, and areas of high flow were formed in midchannel; few parr were observed in midchannel after ice had formed. Through the winter, most parr were found lateral to high flows on the ice edge boundary or in the post-ice period lateral to the stream midchannel. The correspondence of parr movements during winter to changes in the physical habitat associated with ice formation indicates that movements and redistributions may be important for survival affected by ice.

Codes: qual microhab instream hydro

White, R. G., A. E. Bingham, J. H. Milligan, M. A. Brusven, and C. A. Corraino. 1985. Effects of reduced stream discharge on fish and aquatic macroinvertebrate populations. Phase 2. Report OWRT-B-053-IDA(1).

Two man-made test channels were used to investigate the effect of reduction of stream discharge on juvenile rainbow-steelhead trout and invertebrate populations. Wild juvenile rainbow-steelhead trout (Oncorhynchus mykiss) responded to seasonal 95% reductions in discharge by emigrating from the test channel. An intermediate (50%) reduction in discharge during 1980 tests resulted in little change in number or biomass. Most emigration occurred during the first night following the 95% flow reduction and was predominantly upstream. Since aquatic insects drifted catastrophically during the 24 hours following flow reduction, habitat changes, rather than food limitation, are indicated as the causative factor. A poor relationship was observed between facing velocity and the corresponding 0.6 depth velocity utilized in several predictive models. The 95% flow reduction resulted in no decrease in benthic insect density except during spring. However, numbers of Baetis tricaudatus were reduced in all experiments. (See also PB82-243478. Prepared in cooperation with Idaho Water Resources Research Inst., Moscow, (USA).) (DBO).

Codes: experi reach quant migrat hydro trophic

White, R. G., J. H. Milligan, A. E. Bingham, R. A. Ruediger, and T. S. Vogel. 1981. Effects of Reduced Stream Discharge on Fish and Aquatic Macroinvertebrate Populations.

A study was made of the responses of aquatic insects and juvenile rainbow-steelhead trout to flow-related changes in habitat, and of the predictive capability of three hydraulic simulation models that are currently used to make instream flow recommendations. Tests were conducted in the spring, summer, and fall in two large near-natural artificial stream channels having run-riffle channel configurations: one channel was maintained at constant discharge; flow in the second channel was reduced incrementally. Flow reduction produced increased behavioral/catastrophic insect drift which increased at night and varied with season, degree of flow reduction, and type and developmental stage of aquatic insects. Flow reduction also resulted in decreased trout numbers with large test fish more affected than small fish. It appeared that larger trout responded primarily to physical habitat parameters than to a decrease in food availability. No single hydraulic parameter studied (velocity, depth, surface area, wetted perimeter), consistently correlated with test fish response. Flow-related changes in cover, however, appeared to influence juvenile trout habitat utilization. The hydraulic simulation models tested generally predicted the parameters they were designed for accurately, but the models varied in ease of calibration, application, and useful extrapolation range. It was found that transect placements for hydraulic simulation data collection in run-riffle channels were more important than the number of transects used. (Zielinski-MAXIMA).

Codes: quant enclos flow hydro instream hem

Williams, J. G. 1999. Stock dynamics and adaptive management of habitat: an evaluation based on simulations. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 19: 329-341.

Simulations based on the Ricker and Beverton-Holt stock-recruitment models illustrate the difficulties with developing information about the effectiveness of habitat restoration efforts from the relation between measurements of habitat and populations of anadromous fishes. The relation between the two is confounded by density-dependent mortality and variable density-independent mortality and is masked by measurement errors. The simulations are considered in terms of populations of fall-run (ocean-type) chinook salmon Oncorhynchus tshawytscha from the Sacramento-San Joaquin river system of central California, where major federal and state efforts are underway to restore anadromous fish populations, as well as brackish and freshwater ecosystems. The simulations show that to implement effective adaptive management of salmon habitat, these efforts must move beyond a trial and error approach in which efforts to restore salmon habitat will be evaluated by population responses. A more promising alternative is evaluating restoration efforts by identifying and testing hypotheses about the mechanisms or processes that relate the restoration actions to populations.

Codes: modeling popdyn experi instream philosophy warning

Wilzbach, M. A. 1985. Prey availability overrides cover in determining growth and abundance of stream-dwelling cutthroat trout. Dissertation

The abundance and biomass of cutthroat trout (Salmo clarki) have been found to be greater in logged than in forested streams of the Oregon Cascades. Although certain prey taxa increase in abundance following logging, habitat stability generally decreases and cover structures are removed. Research was conducted to examine the manner in which habitat features interact with the prey base to result in greater abundance of the trout in logged streams. Cutthroat trout were more effective in foraging on experimentally introduced prey (Culex spp. larvae) in a logged section of Grasshopper Creek (Lane Co., Oregon) than in a forested section. The differences in efficiency were related to prey size and to the amount of overhead shading and substrate crevices. Mean percentages of prey captured by trout were greater in logged control pools and crevice-covered pools of both sections than in forested control pools. Artificial shading of logged pools reduced capture success by the trout to levels found for trout in forested pools. Relative growth rates of cutthroat trout experimentally confined in pools were also greater in the logged than in the forested reach. Differences in growth rates were primarily due to differences between the reaches in invertebrate drift density. Higher drift density in the logged section probably reflected a greater habitat instability that increases the probability that benthic fauna will occur in the water column where they are more available as prey (DBO).

Codes: experi reach quant trophic instream ripar

Wilzbach, M. A. 1985. Relative roles of food abundance and cover in determining the habitat distribution of stream-dwelling cutthroat trout (Salmo clarki). Canadian Journal of Fisheries and Aquatic Sciences 42: 1668-1672.

Emigration of wild cutthroat trout (Salmo clarki) from laboratory channels over 1-wk trial periods was greater under conditions of low than high food abundance (5 vs. 15% of total trout biomass daily), irrespective of the amount of cover (simulated cover structures added vs. removed). When food abundance was high, emigration of trout was slightly greater under conditions of low than high cover. Cover had no effect on emigration rate when food abundance was low. These experiments suggest that at summer temperatures, food abundance overrides cover in determining the abundance and microhabitat distribution of adult cutthroat trout within a stream.

Codes: experi microhab lab migrat trophic instream

Wilzbach, M. A., K. W. Cummins, and J. D. Hall. 1986. Influence of habitat manipulations on interactions between cutthroat trout and invertebrate drift. Ecology 67: 898-911.

The objectives of this study were to examine the interactions of the riparian setting (logged vs. forested) and prey availability on the prey capture efficiency and growth of cutthroat trout (Salmo clarki) and to determine if the riparian setting influences the impact of trout predation on drift composition. Short-term relative growth rates of cutthroat trout, experimentally confined in stream pools, were greater in a logged than in a forested section of stream. Differences in growth rates were attributed to differences among pools in invertebrate drift density, and to differences in trout foraging efficiency that were related to differences between the sections in the amount of overhead shading and substrate crevices. Mean percentages of introduced prey captured by trout were greater in logged control pools and pools of both sections whose bottoms were covered with fiberglass screening to eliminate substrate crevices than in forested control pools and logged pools that were artificially shaded.

Codes: experi habitat qual popdyn ripar trophic

Wilzbach, M. A., and J. D. Hall. 1984. Prey availability and foraging behavior of cutthroat in an open and forested section of stream. 2516-2522 p.

Past research has established that population abundance of cutthroat trout (Salmo clarki) in small streams of the Pacific Northwest (U.S.A.) differs among sites differing in riparian setting. Standing crops and productivity of the fish is greater in streams with open canopies than in streams bordered by deciduous or coniferous vegetation. The explanation appears to be food-related, as abundance of benthic and drifting invertebrates is also greater in open sites. Results suggest that effect of food abundance overrides that of habitat structure in determining trout growth and abundance patterns, and that interactions between habitat and the prey base occur that regulate how much of the prey base is actually available to the trout for consumption.

Codes: multi reach quant ripar trophic review

Wipfli, M. S. 1997. Terrestrial invertebrates as salmonid prey and nitrogen sources in streams: Contrasting old-growth and young-growth riparian forests in southeastern Alaska, U.S.A. CJFAS 54: 1259-1269.

Terrestrial-derived invertebrate (TI) inputs into streams and predation on them by salmonids (40-180 mm fork length) were measured in six coastal Alaska Stream reaches from April through October 1993-1994; riparian habitat of three stream reaches contained conifer-dominated old-growth (no timber harvesting) and three were alder-dominated young-growth (31 years postclearcutting). Data from pan-traps placed on stream surfaces showed that TI biomass and nitrogen inputs averaged up to 66 and 6 mg.m super(-2).day super(-1), respectively, with no significant difference between habitats. Stomach contents from coho salmon (Oncorhynchus kisutch), cutthroat trout (O. clarki), and Dolly Varden (Salvelinus malma) revealed that TI and aquatic-derived invertebrates(A1) were equally important prey. Additionally, salmonids from young-growth systems ingested a greater TI proportion than those from old-growth systems. There were trends but no significant differences between habitats of TI and AI biomass ingested; but, statistical power was <0.30. Results showed that TI were important juvenile salmonid prey and that a riparian overstory with more alder and denser shrub understory may increase their abundance. Riparian vegetation management will likely have important consequences on trophic levels supporting predators, including but not limited to fishes.

Codes: multi reach qual trophic ripar

Wohl, N. E., and R. F. Carline. 1996. Relations among riparian grazing, sediment loads, macroinvertebrates, and fishes in three central Pennsylvania streams. Canadian Journal of Fisheries and Aquatic Sciences 53: 260-266.

We assessed relations among riparian grazing, sediment loads, macroinvertebrates, and fishes in three streams in adjacent catchments in central Pennsylvania. The catchments consisted mostly of agricultural and forest lands. Lengths of streams subjected to riparian grazing were 2.5 km along Cedar Run and 4.1 km along Slab Cabin Run; there was no riparian grazing along Spring Creek. Median daily discharge and temperatures during summer and winter were significantly different among streams. Annual sediment yields were 113, 255, and 273 t in Spring Creek, Cedar Run, and Slab Cabin Run, respectively. Substrate permeability of potential spawning sites for brown trout (Salmo trutta), and densities of benthic macroinvertebrates were significantly higher in Spring Creek than in the other streams. Densities of wild brown trout were 5-23 times higher in Spring Creek than in Cedar Run and Slab

Cabin Run. Although there were marked differences among streams with and without riparian grazing, other watershed attributes could have had some influence on these streams.

Codes: reach multi graz wtemp substrate quant

Wydoski, R. S., and W. T. Helm. 1980. Effects of Alterations to Low Gradient Reaches of Utah Streams. Fish and Wildlife Service, Biological Services Program Report FWS/OBS-80/14, April, 1980. 178 p.

Stream channels in the semi-arid intermountain west have been modified for many years by agricultural interests, primarily to provide flood protection. Of special concern is the relationship between stream channel modification and the high value fishery resource. This report describes an investigation of the effects of stream channelization on fish and macroinvertebrates in low gradient reaches of Blacksmith Fork River and the Logan River in the floodplain of Cache Valley in northern Utah. Dredged, recently bulldozed, and old bulldozed sites, plus two control areas, were selected for study. Erosion and deposition of streambed gravel were directly correlated with the percentage of stream reach that was altered. High stream flows in spring appeared to be required to maintain the depth and frequency of pools. Channelization adversely affected both fish and macroinvertebrate populations and biomass, with the severity of impact directly related to the amount and duration of disturbance of the physical habitat. In all bulldozed sites the trout populations were not self-sustaining. Dredging had less effect than bulldozing on survival of age 0 fish, but dredging may reduce spawning in the future. Water temperature, water chemistry, sampling information, a macroinvertebrate list, and length and weight information on invertebrates is provided in microfiche appendices. (Moore-SRC).

Codes: multi experi reach quant instream

Wydoski, R. S., and W. T. Helm. 1980. Effects of Alterations to Low Gradient Reaches of Utah Streams: Summary. Fish and Wildlife Service, Biological Services Program Report FWS/OBS-80/13, April, 1980. 17p.

Stream channels in the semi-arid intermountain west have been modified for many years by agricultural interests, primarily to provide flood protection. Of special concern is the relationship between stream channel modification and the high value fishery resource. This report summarizes an investigation of the effects of stream channelization on fish and macroinvertebrates in low gradient reaches of Blacksmith Fork River and the Logan River in the floodplain of Cache Valley in northern Utah. Erosion and deposition of streambed materials were directly correlated with the length of stream that was altered and the type of alteration. Channelization adversely affected both fish and macroinvertebrate populations and biomass, with the severity of impact directly related to the amount and duration of disturbance of the physical habitat. Populations, biomass and production of brown trout and mountain whitefish appeared to be directly related to the proportion of the stream reach that contained pools. (Moore-SRC).

Codes: multi experi reach quant instream

Young, K. A., S. G. Hinch, and T. G. Northcote. 1999. Status of resident coastal cutthroat trout and their habitat twenty-five years after riparian logging. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 19: 901-911.

In 1973 two sections of a small headwater stream containing allopatric nonanadromous coastal cutthroat trout Oncorhynchus clarki were subjected to two types of streamside logging: (1) clear-cut to the streambank with all existing wood and logging debris left in the channel and on adjacent hill slopes (section B; 4.2% gradient), and (2) clear-cut to the streambank with all logging debris and existing instream wood removed from the channel and adjacent hill slopes (section A; 0.8% gradient; termed scarified). A third upstream reference section was undisturbed (section C; 4.8% gradient). The hill slopes of both treatment sections were burned in 1974. Instream habitat (large woody debris and pool percentage), water temperature, and fish populations were assessed intermittently during the following 25 years. Instream habitat, water temperature, and trout density in section B were in all years similar to the upstream reference section, C. In section A, summer maximum stream temperatures reached 30 degree C immediately after logging but had moderated by 1975 and were similar to the reference section by 1983; the proportion of wetted area that was in pools was 14% in 1975, 33% in 1985, and 49% in 1997; trout density was low (0.05 fish/m super(2)) after logging but had returned to the reference level (0.21 fish/m super(2)) by 1983 and was double (0.49 fish/m super(2)) the reference level in 1997. The recent increase in fish density in section A may have been influenced by instream habitat enhancement and riparian thinning conducted in 1985. Trout density in section A is presently similar to that found in a nearby low-gradient stream with an undisturbed riparian zone. Our results suggest that large pieces of wood that are left in and over small streams after logging, although a contravention of current logging regulations in British Columbia, may help protect resident trout populations following riparian logging.

Codes: experi reach quant ripar wtemp lwd temporal